DOCUMENT RESUME

ED 120 507 32 CE 006 813

TITLE Transportation Cluster Volume 3 [Small Power Sources].
INSTITUTION Pennsylvania State Dept. of Justice, Harrisburg. Bureau of Correction.
SPONS AGENCY Office of Education (DHEW), Washington, D.C.
PUB DATE 1 Jan 71
NOTE 131p.; For the rest of the series, see CE 006 811-817

EDRS PRICE MF-$0.83 HC-$7.35 Plus Postage
DESCRIPTORS Adult Vocational Education; Auto Mechanics; Basic Skills; Communication Skills; *Curriculum Guides; Electrical Appliances; Electric Motors; *Engines; General Education; *High School Equivalency Programs; *Integrated Curriculum; Job Skills; Mathematics Education; Mechanics (Process); Occupational Clusters; Science Education; Social Studies; *Transportation; Vocational Education; Vocational Rehabilitation
IDENTIFIERS Elementary Secondary Education Act Title I; ESEA Title I

ABSTRACT

The document is one of seven volumes of instructional materials developed around a cluster of Transportation Industries. Primarily technical in focus, they are designed to be used in a cluster-concept program and to integrate with a regular General Education Development (G.E.D.) program so that students may attain an employable skill level and a general academic background simultaneously. They provide basic skills necessary to enter a number of occupations in the Transportation cluster rather than an indepth development of skill in any one occupation. The volume contains approximately 120 hours of instruction in Small Power Sources and consists of 20 instructional units, each having one or more specific lessons. Each unit is designed for six hours, or one day, of instruction: three hours of technical laboratory instruction and three hours of related study in science, math, communications, and social studies. In most cases, there is only one lesson per unit. The units offer the instructor the essential materials: the aims (both in technical areas and in the four general education areas), instructional aids, topical outline and activities, suggested time sequence, evaluation guidelines, summary, and references. A selected bibliography concludes the volume. (Author/AJ)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED120507

Commonwealth of Pennsylvania

Department of Justice

Bureau of Correction

VOCATIONAL EDUCATION
PROGRAM OF STUDIES

Elementary, Secondary Education Act

Title I

TRANSPORTATION CLUSTER

VOLUME III

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

CE006 813

January 1, 1971

Pennsylvania Bureau of Correction

Harry A. Snyder

Director of Education

INTRODUCTION

The following information comprises one of seven volumes of instructional materials developed around a cluster of Transportation Industries and Occupations. These instructional materials are primarily technical in focus but are written to be used in a cluster concept program as part of an integrated curriculum.

The materials are aimed at preparing students with basic skills necessary to enter a number of occupations in industries within the Transportation cluster rather than providing an in-depth development of skill in any one occupation.

Each volume contains approximately one hundred twenty hours of instruction (about one month of study) and consists of twenty instructional units each having one or more specific lessons. Each unit is designed for six hours of instruction (three hours of technical laboratory experiences and three hours of related study in science, math, communications and social studies) but may be varied at the instructor's discretion.

The seven volumes or cluster areas in the series are:

Volume I - Automotive Services I
II - Automotive Services II
III - Small Power Sources
IV - Driver Training
V - Pneumatics, Hydraulics and Fluidics
VI - Farm and Earthmoving Equipment
VII - Transportation Systems

Students in the Transportation cluster should be introduced to the technical and integrated content through several methods closely related to the industrial structure. Among these are line production and assembly, group projects, experimentation, unit studies and independent study. Team teaching techniques should be employed between the academic specialist and the technical specialist and coordinators.

It is recommended that an orientation program be offered students to familiarize them with the cluster areas available so they may select one they wish to pursue. The cluster instruction is designed to integrate with the regular G. E. D. program so that students may receive an employable level of skill and a general academic background simultaneously.

As students select the technical cluster areas they wish to study, they should have the option to move through the G. E. D. content at their own speed using programmed instructional materials, instructional television, computer assisted instruction and other individualized learning techniques. Technical and integrated concepts are introduced each day by the specialists involved.

After completion of one or more months of study within another cluster providing, of course, this transfer is agreeable with the counselors, coordinators and instructors involved.

Lessons have been identified in the units. In most cases, however, there is only one lesson since each unit is limited to one day or six hours of instruction. The units offer the instructor the essential materials, vis-a-vis the aims, instructional aids, topical outline and activities, suggested time sequence, evaluation guidelines, summary and references. The primary and supplemental references are directly related to the topics and are important to the instructors. A selected bibliography is attached at the end of each volume as recommended additional sources of information.

Pagination of the units in this volume has been identified by cluster (T), volume (I, II, etc.), unit (1, 2, etc.) and page (.1, .2, .3, etc.) within each unit.

TABLE OF CONTENTS

UNIT		PAGE
1	History of Power	T-III- 1.1
2	Energy, Power and Work	T-III- 2.1
3	Contemporary Forms of Power	T-III- 2.1
4	Four-Stroke Cycle Engine Principles	T-III- 3.1
5	Disassembly and Identification of Engine Components	T-III- 5.1
6	Valve System Operation	T-III- 6.1
7	Magneto Ignition System	T-III- 7.1
8	Electrical and Accessory Systems	T-III- 8.1
9	Fuel and Governor Systems	T-III- 9.1
10	Lubrication and Cooling Systems	T-III-10.1
11	Engine Rebuilding and Assembly	T-III-11.1
12	Comparative Analysis of Two-Stroke Cycle Four-Stroke Cycle Engines	T-III-12.1
13	Overhaul of Two-Stroke and Four-Stroke Cycle Engines	T-III-13.1
14	Engine Troubleshooting, Tune-Up and Seasonal Care	T-III-14.1
15	Additional Internal Combustion Power Sources	T-III-15.1
16	Basic Principles of Electric Motors	T-III-16.1
17	Equipment for Testing Electrical Appliances	T-III-17.1
18	Portable Electric Tools	T-III-18.1
19	Appliance Servicing	T-III-19.1
20	Troubleshooting and Maintenance of Electric Tools and Equipment	T-III-20.1
Bibliography		t-III-i

INSTRUCTOR'S UNIT PLAN

Unit 1
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **History of Power**

AIM: To develop student awareness of developmental changes in methods of accomplishing work. The resultant freeing of man from labor and how it has allowed him to improve society.

INSTRUCTIONAL AIDS:

Illustrations of sources of power during early history of man, models, charts. Examples of: Pulley and rope, screw, fulcrum/lever, axle and wheel, inclined plane, gears.

Film - **Gears,** 146-01 Archer Avenue, Jamacin, New York: Eye Gate House, Inc. (12 minutes).

Film - **Inclined Plane, Wedge and Screw,** 146-01 Archer Avenue, Jamacin, New York: Eye Gate House, Inc. (12 minutes).

Film - **Wheel and Axle,** 146-01 Archer Avenue, Jamacin, New York: Eye Gate House, Inc. (12 minutes).

EQUIPMENT:

16 mm projector and screen.

PRIMARY REFERENCES:

1) Barnard, J. Darrell, **Science: A Key to the Future,** New York: The Macmillan Company, Publishers, 1962.

2) Duffy, Joseph W., **Power: Prime Mover of Technology,** Bloomington, Ill: McKnight & McKnight Publishing Company, 1965.

3) Kettering, Charles F., **Short Stories of Science and Invention,** Detroit 48202: General Motors Corporation, 1969.

4) Rosskopf, Myron F., **Modern Mathematics for Jr. High School,** New Jersey: Silver Burdett Company, 1961.

5) Stephenson, George, **Power Mechanics,** Albany, New York: Delmar Publishers, Inc., 1963.

6) **Story of Power, The,** Detroit 48202: Public Relations Staff, General Motors Corporation, 1956.

I. INTRODUCTION and MOTIVATION

Show models and illustrations of early man at his labors and his progress until the invention of the steam engine (1700). Use models, charts, and illustrations to identify labor-saving devices for man until the invention of the steam engine.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Early man	1. Developed and utilized weapons that were an extension of his Arm, i.e.: Club, Hammer, Spear. 2. Early man had only his own muscle to depend upon.	1. Man's potential energy without any type of assistance. 2. Energy as the ability to do work.
B. New stone age	1. Man became farmer. 2. Domesticated animals. 3. Now used animals for power. 4. Man settled to agriculture in the fertile valleys. a. Man turned from collector of food to producer of food. b. This allowed a production of surplus food and products so some specialization began to occur. 5. Animals domesticated by man were used for agriculture, food, protection, and transportation.	1. Man's potential energy with animal help.
C. Multiplication machines	1. Gears. 2. Inclined plane. 3. Lever and fulcrum. 4. Screw. 5. Wedge. 6. Wheel and axle. 7. Simple machine (engine) was developed by man to assist and multiply his limited muscle power. 8. To improve, man was forced to develop new power sources.	1. Potential and kinetic energy. Multiplication of energy by these uses. 2. Man's ability to transfer many types of energy to mechanical energy.
D. Water power	1. Water wheel. 2. Turbines. 3. Man discovered methods of making flowing water work for him. a. Undershot water wheel was first. b. Water wheel design improved. c. Effects of water power on building of cities.	1. Water's molecular composition. 2. Water as a potential and kinetic energy source. 3. Electrical power. a. Nature of b. Characteristics of

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Multipation of force due to extension of arm.	1. Library research for references that describe these Periods. a. Encyclopedia b. History books c. Technical journals 2. Use of card catalog and reader's guide.	1. Early civilizations and their location. Man depended on geographical factors such as availability of water, natural protection, and food resources.
1. Horsepower, what it is and formulas that can be used to show work being accomplished.	1. Write essays pertaining to early man's problems and solutions. 2. Begin a dictionary of words pertaining to the small engine, its application, maintenance and overhaul.	1. Uses of human and animals by the ancient civilizations. Where early man was dependent upon the use of animals, he was limited to those which were available in his region.
1. Mechanical advantage. a. Gears. b. Inclined plane. c. Lever and fulcrum. d. Screw. e. Wedge. f. Wheel and axle. 2. Everyday examples and applications of simple machines.	1. Research and development of how these early inventions are used today. a. Written presentation b. Oral presentation	1. Who invented the devices for mechanical advantages. 2. What practical application was found for each labor-saving device? How did this affect: a. The economy b. Use of leisure time
1. Force, work, area, radius, diameter, circumference formulas and where they might be utilized. 2. Weight of water and how that weight can be used.	1. Develop vocabulary of parts and types of water wheels and turbines.	1. Physical features of land and its effect upon water supply. 2. Why people settled near oceans and rivers. Effect upon the location and development of cities and towns.

II. PRESENTATION of INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
	4. Water turbines allowed development of hydroelectric power. These power plants must be located near large water supplies.	
E. Wind power.	1. Land. 2. Sea. 3. Development of the windmill to derive power. 4. Sailboat made possible the interaction of early civilizations and development of commerce.	1. Composition of air. a. Effects of air pressure. b. Effects of vacuum. 2. How wind could cause sailboat or windmill to operate.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Vectors a. As used with stationary windmill. b. As used with moving sailboat. 2. Navigation of oceans. a. Celestial. b. Line of sight.	1. Language a. Word derivation. b. How etymologies developed.	1. Prevailing winds a. Effects on city location. b. Effects on development of industry or seaport.

III. APPLICATION

A. Students should test mechanical advantage produced by items such as pulley and rope, inclined plane.

B. Students should be aided in construction of model windmills, water wheels, turbines.

C. Fly kites, make land (wheeled) sailboats (prairie schooners) to show utilization of power of air.

D. Student reports on research on areas of study.

IV. EVALUATION CRITERIA GUIDELINE

A. Questions on major developments during the history of power.

B. Questions on present day uses of early power developments.

C. Use of formulas to solve simple problems.

D. Why cities developed as they did.

E. Do cities develop in same areas for same reasons as in the olden days?

V. SUMMARY

A. Man developed from food gatherer to food producer.

B. Simple machines invented to make man capable of accomplishing more work.

C. Engine - converts energy into work.

D. Reason for location of early cities.

E. Turbines - development of hydroelectric power.

F. Man must continue to seek other sources of energy.

VI. SUGGESTED TIME and SEQUENCE LISTING

60 minutes . . . Instructional topic: Early man.

48 minutes . . . Social studies: Early man's living areas.

12 minutes . . . Film: **Inclined Plane, Wedge and Screw.**

30 minutes . . . Science concepts of simple machines.

30 minutes . . . Math, how force is multiplied through extension: Vocabulary and formulas.

12 minutes . . . Film: **Wheel and Axle.**

12 minutes . . . Film: **Gears.**

36 minutes . . . Science: Energy.

60 minutes . . . Water and wind utilization.

60 minutes . . . As required to develop specific areas of integrated concepts.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Adler, Irving J., **The Wonders of Physics,** New York: Golden Press Publishers, 1966.

2) Blackwood, Paul E., **Push and Pull: The Story of Energy,** New York: McGraw-Hill Book Company, Inc., 1959.

3) Branley, Franklyn M., **Solar Energy,** New York: Thomas Y. Crowell Company, 1959.

4) Buehr, Walter, **The First Book of Machines,** New York: Franklin Watts, Inc., 1962.

5) Coombs, Charles, **Lift Off: The Story of Rocket Power,** New York: William Morrow & Company, Inc., Publishers, 1963.

6) De Camp, L. Sprague, **Engines: Man's Use of Power From the Water Wheel to the Atomic Pile,** New York: Golden Press, Publishers, 1959.

7) De Camp, L. Sprague, **Man and Power: The Story of Power From the Pyramids to the Atomic Age,** New York: Golden Press, Publishers, 1961.

8) Epstein, Samuel and Beryl, **All About Engines and Power,** New York: Random House, Inc., 1959.

9) Harrison, George R., **The First Book of Energy,** New York: Franklin Watts, Inc., 1965.

10) Irving, Robert, **Energy and Power,** New York: Alfred A. Knopf, Inc. 1958.

11) Irwin, K. G., **The Romance of Physics,** New York: Charles Scribner's Sons, 1966.

12) Marcus, Abraham and Rebecca B., **Power Unlimited,** Englewood Cliffs New Jersey: Prentice-Hall, Inc., 1959.

13) Meyer, Jerome S., **Machines,** New York: The World Publishing Company, 1956.

14) Moore, Jordan, **Living Science: Energy,** New York: Grosset & Dunlap, Inc., 1968.

15) Posin, Daniel Q., **What is Energy?,** Chicago: Beckley-Cardy Company, 1968.

16) Schneider, Herman and Nina, **More Power to You,** New York: William R. Scott, Inc., 1958.

17) Sharp, Elizabeth N., **Simple Machines and How They Work,** New York: Random House, Inc., 1962.

18) Stephenson, George, **Power Mechanics,** Albany, New York: Delmar Publishers, Inc., 1963.

19) Stoddard, Edward, **The Story of Power,** New York: Garden City Books, 1958.

20) Syrocki, B. John, **What Is a Machine?,** Westchester, Ill.: Benefic Press,

INSTRUCTOR'S UNIT PLAN

Unit 2
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Energy, Power and Work**

AIM: To develop an understanding of the concepts of energy, power and work, and have the student become familiar with basic vocabulary and formulas necessary to identify and complete problems concerned with small thermal and electrical power sources.

INSTRUCTIONAL AIDS:

Charts, graphs, illustrations, models and pictures describing simple machines such as gears, inclined plane, pulley, screw, wedge, wheel and axle. Also those which would describe energy, horsepower, power and work.

EQUIPMENT:

Overhead projector, 16 mm projector and screen.

PRIMARY REFERENCES:

1) De Camp, L. Sprague, **Man and Power: The Story of Power from the Pyramids to the Atomic Age,** New York: Golden Press, Publishers, 1961.

2) Duffy, Joseph, **Power: Prime Mover of Technology,** Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

3) **General Theory of Operation,** Milwaukee: Briggs & Stratton Corporation (Manual).

4) **Power Goes to Work,** Detroit: General Motors Corporation (Booklet).

I. INTRODUCTION and MOTIVATION

A. Guide student discussion into the many sources of energy used to produce power.

B. Discuss the origin and production of energy.

C. Preview pictures and illustrations that will be used. Direct the student's attention to those terms that will be new giving examples to reinforce them. Utilize student background to develop the terms.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Energy	1. Kinetic and Potential. 2. Energy is the source drawn upon to accomplish work. a. Energy can be stored in bodies of matter. b. Potential energy, stored due to chemical state, condition or position of body.	1. The solar system. a. Need for sun. b. What sun gives to the earth. c. Kinetic and potential energy.
B. Potential energy for the engine	1. Stored in the fuel. 2. Change in energy form. 3. Reaction of confined heat energy. 4. Change in name of energy when energy changes form, now kinetic energy.	1. Refining of crude oil to usable fuels. a. Gasoline b. Diesel c. Others d. Release of energy by fuels e. Crude oil as a mixture of various hydrocarbons. f. Fractional distillation
C. Definition of power	1. Its measurement. 2. Defined as horsepower. 3. Power: rate at which work is accomplished. a. Power is therefore rate of doing work. b. Energy conversion rate equal power. 4. Horsepower rating developed by James Watt. a. Comparison of horse work ability to that of his steam engine. 5. Horsepower now common basis for accomplishment of work. a. Few machines not rated by horsepower.	1. Effects of different fuels on the power output of devices. (Controlled combustion experiments). a. Controlled burning vs. detonation. b. Different heats from different fuels under controlled contions. c. Effects of air-fuel mixture ratios. d. Oxygen as an essential ingredient in combustion.
D. Work	1. How measured a. Work equals Force x distance. b. Inch-pounds (W equals Weight x inches) c. Foot-pounds (W equals Weight x feet) 2. Two meanings of work: a. Man's labor b. Machines moving objects. 3. Motion resulting from application of a force is called work 4. Work: units of measurement, Inch and Foot pound	1. Pressures developed in a closed container when fuel is burned. a. Study of structure of each fuel b. Which will produce the most usable heat c. Laws of Gases. d. Compressibility and expandability of gases.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Time and distance problems based on Solar System. a. Revolution and rotational motions of plonets. b. Calculations with large numbers using exponents	1. Oral or written description of the different areas of the earth. a. What causes them? b. Can these areas be changed? c. What effect might these changes have on the life styles we now know?	1. Solar radiation on different parts of the earth and its effects on social and economic habits. a. Seasons. b. Unique results of having or not having sun. 2. Relationship to ways of satisfying needs for food, clothing, shelter.
1. Percentages (fuel from crude) 2. Ratios (expanding gases to cool gases). Usable fuel-air ratios.	1. Write letters to oil companies for information about refining, drilling, research, etc.	1. Geographic locations of energy deposits: a. Oil b. Coal c. Other 2. Relation of desposits to the development of cities and transportation centers.
1. Formulas: a. Area of circle. b. Cubic displacement. c. Volume of various solids. d. Measurement systems. e. Centigrade to Fahrenheit conversion. f. Metric to English conversion.	1. Vocabulary building: a. Key words in measurement b. Key words in power production 2. Library research on different measuring systems. 3. Creative writing including information on measurement conversion.	1. Where was the English measurement system derived. a. Period of history. b. Type of government. c. Effect of this new system on peoples of that time. 2. Through the use of power, man is able to produce more than he could using only human or animal power.
1. Pressure per square unit. a. Pressure developed on a piston head. b. Compression ratios. c. Horsepower computation.	1. Illustrated talks on how to rebuild an engine for more horsepower or better operation. 2. Develop guidelines for taking notes on classroom presentations.	1. Locations of manufacturing and processing center: a. Why they are there. b. Effect on local peoples.

II. PRESENTATION of INTEGRATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	RELATED CONCEPTS SCIENCE
E. Engines - Work	1. Engines use energy to develop mechanical power. 2. Mechanical power used to apply force. 3. Force moves machinery thereby accomplishing work.	1. Study of engine efficiency due to fuels. a. Effect of cooling.
F. Mechanical advantage (MA)	1. To dfine: MA equals L divided by E 2. Law of machines: MA equals DE divided by DC 3. As applied to machines leverage is called mechanical advantage. a. Mechnaical advantage of a machine is the number of times it multiplies force. There is no production of mechanical force in this machine. 4. The Law of Machines. a. Output is equal to input (minus any frictional loss).	1. Study of space environment: a. Nature's obedience to laws of motion b. Action and reaction c. Inertia d. Friction and how it can be controlled.
G. Simple machines.	1. Lever a. MA equals EF divided by LF b. Classes 1) First 2) Second 3) Third 2. Lever Rigid device which pivots on point called fulcrum. Fulcrum between effort and resistance 3. Fulcrum at one end, resistance between fulcrum and effort. 4. Fulcrum at one end, resistance at other end, effort applied to middle. 5. Gears, pulleys, sprockets a. Gear types b. Gear parts c. Gear ratio d. MA equals Number of output teeth / Number of input teeth	1. Practical uses for the simple machines historically as well as today. 2. Metallurgy a. Additives b. Resultant strength c. Need for different metals

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Begin study of mechanical advantages thru such devices as fulcrum and lever.	1. Develop definitions of the word "Force." 2. Reinforce word meaning with vocabulary study.	1. What were the first engines? a. How used? b. Where used? c. Any change on the people of the world?
1. Continue study of other simple machines. (Student activities involving observation, measurement, and calculations.)	1. Discuss the term "law" to discover its several meanings and applications to this topic.	1. Which peoples of the world use these factors more productively? a. Effect on peoples. b. Advancement in technology these developments have fostered. 2. Advantages to nations having highly developed technology.
1. Problems concerning all simple machines individually. Mechanical advantage. 2. Ratios. Formula application.	1. Research for peoples that still use the simple machines. 2. Vocabulary development.	1. Do all countries have ability to process metals? If not, what is the effect? 2. Industrialization of nations according to their ability to develop simple machines.

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	RELATED CONCEPTS SCIENCE
	e. MA equals $\frac{\text{Diameter of output pulley}}{\text{Diameter of input pulley}}$ f. A gear is actually a simple lever eventhough it is round. 6. Wheel and axle a. MA equals $\frac{\text{Input circumferance}}{\text{Output circumferance}}$ b. Another form of the lever 7. The pulley a. Stationary b. Movable c. Combination d. Application of weight turns pulley about axle. 8. Inclined plane a. MA equals $\frac{\text{Length of incline}}{\text{Vertical height to (highest point)}}$ b. Inclined plane: diagonal of rectangle or square always. c. Ma equals $\frac{\text{Length of base}}{\text{Height to top}}$ d. Less than 90° 9. Screw MA equals $\frac{2\ R}{P}$ 10. Modified inclined plane Thread pitch the same as inclined plane. 11. Worm gear a. MA equals $\frac{\text{Worm shaft circumference} \times \text{Number of worm gears}}{\text{Worm gear shaft circum.}}$ b. An application of the screw.	
H. Velocity in basic machines	1. Change in force results in change of speed, the reverse is also true.	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES

III. APPLICATION

A. Assign students specific gear ratios, mechanical advantages desired or similar problems, for solving.

B. Assign problems with circumference of gears and number of teeth for solving.

C. Assign problems requiring students to change gear ratios or mechanical advantage to better accomplish specific jobs.

IV. EVALUATION CRITERIA GUIDELINE

A. Vocabulary identification evaluation.

B. Evaluate student's ability to solve single power formulas.

C. Students should be required to identify the different items studied.

V. SUMMARY

A. Energy, the ability to accomplish work.
   1. Forms of energy:
      a. Kinetic
      b. Potential

B. Work: force required to move an object.

C. Rate of doing work: Power.

D. Common method to determine how much power is being produced: Horsepower.

E. Simple machines:
   1. Gear
   2. Lever (mechanical advantage)
   3. Screw (inclined plane)
   4. Wheel and axle (lever like)

VI. SUGGESTED TIME and SEQUENCE LISTING

30 minutes . . . Introduction to topic and motivation.

180 minutes . . . Technical experiments with energy, work and power.

150 minutes . . . Related study of concepts in math, science, communications and social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Adler, Irving, **Machines**, Eau Claire, Wisc.: E. M. Hale and Company, 1964.

2) Blackwood, Paul E., **Push and Pull: The Story of Energy**, New York: McGraw-Hill Book Company, Inc., 1959.

3) Branley, Franklyn M., **Solar Energy**, New York: Thomas Y. Crowell Company, 1959.

4) Buehr, Walter, **The First Book of Machines**, New York: Franklin Watts, Inc., 1962.

5) Calder, Ritchie, **Evolution of the Machine**, Eau Claire, Wisc.: E. M. Hale and Company, 1968.

6) Dull, Charles E., **Modern Chemistry**, New York: Holt, Rinehart & Winston, Inc., 1960.

7) Hogben, Lancelot, **The Wonderful World of Energy**, New York: Doubleday & Company, Inc., 1959.

8) Notkin, Jerome J. and Gulkin, S., **How and Why Wonder Book of Machines**, New York: Grosset & Dunlap, Inc., 1960.

9) Robbin, Irving, **How and Why Wonder Book of Basic Inventions**, New York: Grosset & Dunlap, Inc., 1965.

10) Schneider, Herman, **Everyday Machines and How They Work**, New York: McGraw-Hill Book Company, Inc., 1950.

11) Stephenson, George, **Small Gasoline Engines**, Albany, New York: Delmar Publishers, Inc., 1964.

INSTRUCTOR'S UNIT PLAN

Unit 3
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Contemporary Forms of Power**

AIM: To develop an understanding of the forms of power in use today and the reasons for selecting the type of power for specific tasks.

INSTRUCTIONAL AIDS:

Film - **Building Boilers for Ships**, 200 Madison Avenue, New York: Combustion Engineering, Inc. (Rental, 40 minutes, 16 mm).

Film - **Steam for Power**, 161 East 42nd Street, New York: Babcock and Wilcox Company (Free rental, 41 minutes, 16 mm).

Film - **Steam Turbine, The**, 116 Natoma Street, San Francisco: Photo and Sound Company (Rental, 1 reel, 16 mm).

Film - **Diesel Story**, 50 West 50th Street, New York: Shell Oil Company, Public Relations Department (Free, 19 minutes, 16 mm).

Film - **Diesel - The Modern Power**, Box 177, North End Station, Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations (Free, 21 minutes, 16 mm).

Film - **ABC of the Automobile Engine**, Box 177 North End Station, Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations (Free, 18 minutes).

Film - **ABC of the Diesel Engine**, General Motors Corporation (Free, 22 minutes).

EQUIPMENT:

16 mm projector, screen, models, charts and illustrations pertinent to lesson.

PRIMARY REFERENCES:

1) Duffy, Joseph W., **Power: Prime Mover of Technology**, Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

2) Kettering, Charles F., **Short Stories of Science and Invention**, Detroit 48202: General Motors Corporation, Public Relations Staff, 1969.

3) **Story of Power, The**, Detroit 48202: General Motors Corporation, Public Relations Staff, 1956.

I. INTRODUCTION and MOTIVATION

A. Discuss how the world would exist if all forms of power or power development were suddenly removed.

B. Identify contemporary power sources through student discussion.

C. Discuss employment possibilities connected with each of the several power sources.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Water power 1. Hydroelectric power 2. Location limitations	1. Electric power is developed by changing water power to mechanical power then to electric power. 2. Large and continuous water supply necessary.	1. Atomic structure. 2. Electrical generation. a. Conductivity b. Insulators
B. Steam 1. External combustion engine 2. History of steam engine development 3. Uses today	1. Converts water to steam; this is used to accomplish the work . 2. From Hero to the present time. a. First an interesting toy. b. Became useful after refinement by James Watt. c. Not tied to source of fuel or water. 3. With turbine for: a. Ships b. Pumps c. Electric generation	1. Impurities in water: How to purify: a. Distillation b. Filtration c. Sedimentation 2. Characteristics of steam and how it can be used.
C. Electrical 1. External power source a. Flexibility b. Use	1. Electric power transmission. 2. Electrical motors a. From small to large b. Easy mounting c. Portability of electric motors 3. To power things from watches to locomotives.	1. Magnetic and electromagnetic fields and effects. 2. Magnetic and electromagnetic fields as applied to the electric motor.
D. Internal combustion 1. Internal power source 2. Flexibility 3. Use	1. Power developed within cylinder. 2. Only restriction is source of oxygen. 3. (Indirectly) below water to limits of oxygen supply above earth.	1. Burning of fuels. 2. Why oxygen is necessary for fuel burning.
E. Atomic power 1. Develops heat 2. Steam	1. Atomic power is another form of heat energy. 2. Used much the same as a steam heating boiler for external steam engine or steam turbine.	1. Atomic energy: a. Fission b. Fusion 2. Release of power 3. Heat exchangers.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Ohm's Law 2. Calculating watts and kilowatts.	1. Vocabulary of electrical plant.	1. Where hydroelectrical plants could be located. 2. What are the geographical features required for their location?
1. Formulas based on gas laws.	1. Vocabulary of steam engine. 2. How to read and interpret instruments and gauges.	1. Study of effects steam engines had upon civilization from earlier times to the present time.
1. Ohm's Law application. a. Volt b. Ampere c. Ohm	1. Vocabulary of electrical motors and devices. 2. Develop a research-experiment project related to electricity.	1. Effect of electrical power on civilization. 2. Comparison of modern civilizations with and without electrical power.
1. Futher development of formulas for the determination of horsepower.	1. Vocabulary related to the internal combustion engine. 2. Develop guidelines for note-taking on films shown in class.	1. Effect of the internal combustion engine on civilization. 2. Problems created by the internal combustion engine 3. Effect on a society highly dependent on transportation.
1. Review vectors using steam impact on turbine as basis for study.	1. Collect newspaper and periodical articles related to atomic power uses for peacetime. 2. Discussion of other forms of power: a. Political b. Social c. Economic 3. Written exploration of the similarities of power in the technical field and the social field.	1. Disposition of waste problems. 2. Where is the uranium used located? 3. Possible change effect upon civilization. 4. Potential for improving man's way of life.

III. APPLICATION

A. Have students:
1. Design a hydroelectric plant.
2. Design a steam engine or turbine.
3. Draw the fields and their reaction patterns in an electric motor.
4. Orally, pictorially or graphically describe how a diesel locomotive operates.

B. Write a short series of paragraphs discussing how civilizations change due to the development of various power sources.

IV. EVALUATION CRITERIA GUIDELINE

A. Identification of parts of power sources machinery when shown pictorially.

B. Utilize formulas for determining area, volume, pressures, resistance, voltage and amperage.

C. Identify changes brought about by the development of each power source.

D. Ability to describe safety requirements necessary to utilize each of the power sources.

V. SUMMARY

A. Use of water, steam, electricity, the internal combustion engine and atomic power for power.

B. Continuing need for development of sources of power.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communications.

45 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Barnard, J. Darrell, **Science: A Key to the Future,** New York: The Macmillan Company, Publishers, 1962.

2) Barr, Donald, **Atomic Energy,** Columbus, Ohio: Charles E. Merrill Books, Inc., 1961.

3) Branley, Franklyn M., **Solar Energy,** New York: Thomas Y. Crowell Company, 1959.

4) De Camp, L. Sprague, **Engines: Man's Use of Power from the Water Wheel to the Atomic Pile,** New York: Golden Press, Publishers, 1959.

5) De Camp, L. Sprague, **Man and Power: The Story of Power from the Pyramids to the Atomic Age,** New York: Golden Press, Publishers, 1961.

6) Meyer, Jerome S., **Machines,** New York: The World Publishing Company, 1958.

INSTRUCTOR'S UNIT PLAN

Unit 4
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Four-Stroke Cycle Engine Principles**

AIM: To develop an understanding of the principles of operation of the four stroke cycle engine and the materials used in power plant construction.

INSTRUCTIONAL AIDS:

Film - **How Metals Behave,** 7301 Euclid Avenue, Cleveland, Ohio: American Society of Metals (Rental, 30 minutes, 16 mm).

Film - **Story of Perfect Circle Piston Rings,** 552 S. Washington Street, Hagerstown, Ind.: The Perfect Circle Corporation, School Assistance Department (Free, 18 minutes, 16 mm).

Film - **ABC of the Automobile Engine,** Box 177 North End Station, Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations.

Film - **ABC of the Diesel Engine,** Box 177 North End Station, Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations (Free, 20 minutes, 16 mm).

Film - **ABC of Internal Combustion,** Box 177 North End Station, Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations (Free, 13 minutes, 16 mm).

Film - **Automotive Broaching,** 29 West 39th Street, New York: American Society for Mechanical Engineers.

Film - **Diesel Story,** 50 W. 50th Street, New York: Shell Oil Company, Public Relations Department (Free, 19 minutes, 16 mm).

Film - **Diesel, The Modern Power,** Box 177 North End Station, Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations (Free, 21 minutes, 16 mm).

Models, charts, illustrations related to the lesson.

EQUIPMENT:

16 mm projector and screen.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement,** Milwaukee: Briggs & Stratton Corporation.

2) **General Theories of Operation,** Milwaukee: Briggs & Stratton Corporation.

3) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., 1960.

4) Stephenson, George, **Small Gasoline Engines,** Albany, New York: Delmar Publishers, Inc., 1964.

I. INTRODUCTION and MOTIVATION

A. Introduce film(s) (Preview and select from aids listed or other sources). Relate the content to the lesson objectives.

B. Develop an understanding of the expert mechanic. (If the mechanic knows all the facets of the engine from the foundry through troubleshooting, he will be the best mechanic.)

C. Develop an understanding of the materials and how they are selected for use in the manufacture of the small gasoline engine.

D. Develop an understanding of the four stroke cycle engine through the sequence of events as the piston reciprocates in the cylinder.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Engine construction materials. 1. Metals utilized 2. Reasons	1. Specific characteristics of metals. a. Exterior b. Interior 2. Weight to horsepower ratio of engines.	1. Atomic structure of metal. a. Atomic bond. b. Relationship to weight. c. Crystalline structure. 2. Concept of matter and mass.
B. Methods for forming parts. 1. Internal combustion engines. 2. External combustion engines.	1. Processes best suited. a. Casting b. Forging c. Broaching d. Other processes 2. Reason for process. a. Strength b. Production considerations	
C. Four stroke cycle.	1. Piston motion (stroke) a. Intake b. Compression (ignition-event) c. Power d. Exhaust	1. Boyle's Law 2. Kinetic energy of gases. 3. Bernoulli's Princle. 4. Charles' Law.
D. Crankshaft 1. Construction 2. Utilization	1. Material. 2. Forming process and engine fitting. 3. Name of each surface and its use. 4. Use in relation to total engine.	1. Atomic arrangement in stress after forming of a metal. 2. Various techniques for shaping metals.
E. Piston. 1. Construction 2. Utilization	1. Material. 2. Forming process and engine fitting. 3. Name of each surface and its use 4. Use in relation to total engine.	1. Metallic densities of metals. 2. Absorption characteristics of metals due to density. 3. Changes in properties of metals due to heating and vibration.
F. Piston pin and connecting rod. 1. Construction 2. Utilization	1. Material. 2. Forming process and engine fitting. 3. Name of each surface and its use. 4. Use in relation to total engine.	1. Shape-strength relationship: a. Design b. Metal choice

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Formula development for weight and balance of mass. a. Linear. b. Circular.	1. Write letters to specific companies requesting information on: a. Metals b. Processes c. Construction d. Application of product	1. World location of mineral deposits. 2. Transportation involved in transferring minerals to a refining processer. 3. Implications for conservation.
1. Development of pressure . . . through: a. Hydraulics 1) Pascal's Law 2) Hydraulic machines b. Rotary motion 1) Air 2) Electric 2. Formulas required to arive at pressures desired.		1. Location of raw material processing plants in United States. a. Why the location? b. Would other locations serve?
1. Volume ratios a. Finding knowns. b. Finding unknowns.	1. Explore the need for and uses of classification systems. 2. Become familiar with engine model and serial number classification schemes.	1. Effects of power sources on economy. 2. Rural economy. 3. Urban economy.
1. Concept of presseur a. When not confined. b. Confined and acting upon a specific areas.		1. Industrial development as an equalizer in the Social Status of people. 2. Identify differences with countries having power level of development. a. Standard of living b. Dependency upon other nations.
1. Pressure transfer to specific areas using piston-cylinder-ratio. 2. Force and vector diagrams applied specifically.	1. Read and analyze for organization, various kinds of operation and care manuals. 2. Begin design and content development for owners operation and care manual; applicable to engine being utilized in the instruction.	
1. Vectors transfering developed forces within a confined operating area.	1. Vocabulary development for the metals processes being developed.	1. Occupations involved in production.

II. PRESENTATION of INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
G. Piston rings. 1. Construction 2. Utilization	1. Material. 2. Forming process fitting. 3. Name of each surface and its use 4. Use in relation to total engine.	1. Heat treating for metals. a. Concept b. Heat to anneal. 2. Heat transfer. b. How to choose 3. Melting point of materials.
H. Cylinder block and head. 1. Larger engines. 2. Small engines. 3. Heat transfer.	1. Materials. a. Large engines (most are cast from a form of iron). b. Small engines, (mostly cast from aluminum alloy). 1) Choice of material. 2) Effect of choice. 2. Heat transfer. a. Large engines (usually coolant). b. Small engines (usually air-cooled).	1. Effects of high combustion temperatures on materials and how these effects can be minimized.
I. Related parts. 1. Flywheel, ignition system. 2. Fuel system. 3. Other.	1. Materials. a. Why chosen? b. Resultant effect upon the total engine.	1. Concept of mass. a. Rotational effect. b. Energy absorption transfer.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Specific metals heat conductivity ability. a. Formulas utilized. b. Choice of thickness of materials.	1. Discuss uses of audio-visual aids in improving communication. 2. Gather materials for bulletin boards showing the place of power in the modern U. S. civilization. a. Develop separate boards for: 1) Power in general. 2) Specific applications of a single power source.	
1. Computing combustion temperatures.		1. Consumer value of small gasoline engines.
1. Centrifugal (Centripetal) force. a. Formulas. b. Effect. c. Methods of adjustment.	1. Short descriptive narrations (written or oral) that would clarify a part, process or accomplishment utilized to this point.	1. Magnitude of the automotive and small engine parts industry. 2. Effect upon economy of the nation as evidenced during strikes.

III. APPLICATION

A. Students should identify the units and the specific uses for each section (surface or other).

B. Students should identify materials that are used in the construction of power plants.

C. Have students draw a simple engine showing the relative position of the units discussed.

D. Disassemble, inspect and reassemble a small engine.

IV. EVALUATION CRITERIA GUIDELINE

A. Performance, identification of sections (surface or other) on unit.

B. Questions covering vocabulary introduced during the unit.

C. Identification of processes used in the manufacturing of small engines.

D. Questions covering the four strokes of the cycle and the ignition event.

V. SUMMARY

A. Materials and processes used in manufacture of small engines.

B. Four stroke cycle and ignition event.

C. Piston, piston pin, connecting rod, rings and connecting rod and piston rings.

D. Related parts construction.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics, technical concepts.

60 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communications.

30 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Dull, Charles E., **Modern Chemistry**, New York: Holt, Rinehart & Winston, Inc., 1960.

2) Epstein, Samuel and Beryl, **All About Engines and Power**, New York: Random House, Inc., 1962.

3) Moore, Harry D. and Kibbey, Donald R., **Manufacturing Materials and Processes**, Homewood, Ill.: Richard D. Irwin, Inc., 1965.

4) Rogers, Eric M., **Physics for the Inquiring Mind**, Princeton, New Jersey: Princeton University Press.

5) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia**, Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

6) Zim, Herbert S., **What's Inside of Engines?** New York: William Morrow and Company, Inc., Publishers, 1953.

INSTRUCTOR'S UNIT PLAN

Unit 5
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Disassembly and Identification of Engine Components**

AIM: To identify the major components of the engine and acquaint the student with recommended procedures, tools and equipment for disassembling an engine.

INSTRUCTIONAL AIDS:

Film - **An Introduction to Heat Engines,** 149-07 Northern Blvd. Flushing, New York: Shell Oil Company, Film Library (23 minutes).

Film - **ABC of Internal Combustion.** Detroit: General Motors Corporation, Public Relations Staff, Film Library, General Motors Building (13 minutes).

Transparencies - **Internal Combustion Engine M-52,** 4665 Stenten Avenue, Philadelphia: DCA Transparencies.

Transparencies - **Four-Cycle Engine #1041, Two-Cycle Engine #1040,** (3m), 509 Central Avenue, P. O. Box 6100, Charlestown, West Virginia: Business Products Sales, Inc.

Miscellaneous illustrations, charts, pictures concerning internal combustion engines, cutaway models of two and four-cycle engines.

EQUIPMENT:

Benches for disassembly work (48" station per team). Operating engines for student disassembly (suggest Briggs & Stratton engines). Fuel and oil receptacles for waste fuel and oil. 35 mm slide projector and screen. Hand tools for engine disassembly and reassembly.

PRIMARY REFERENCES:

1) **A Power Primer,** Detroit: General Motors Corporation.

2) **Briggs & Stratton Repair Instruction III and Supplement,** Milwaukee: Briggs & Stratton Corporation.

3) Duffy, Joseph W., **Power: Prime Mover of Technology,** Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

4) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., 1960.

5) **Small Engine Service Manual,** 1014 Wyandotte Street, Kansas City, Mo. 64105: Technical Publications, Inc.

6) **Story of Power, The,** Detroit: General Motors Corporation.

I. INTRODUCTION and MOTIVATION

A. As students enter room, give each a sheet of paper to write down names of engine parts which they have previously disassembled and displayed. Commend the student who gets most names correct.

B. Show film: **ABC of Internal Combustion,** then follow with transparencies to show relationship of engine parts.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Use of specifications and repair manuals.	1. How to locate information. 2. Reading of schematics. 3. How to follow step-by-step procedures from manual.	
B. Preparation for disassembly.	1. Identify system service points. 2. Need to drain oils and fuels before disassembly. 3. Systematic procedures.	1. Effects of stale gasoline on engine components. 2. Effects of friction, vibration, and heat on engine components.
C. Removal, inspection, and service of components.	1. Identification of components. 2. Correct procedure for removal of component. 3. Proper tool selection. 4. Short term storage of unit. 5. Ability to identify parts needs to others thru proper technical language. 6. Ability to identify tool needs to others thru proper technical language. 7. Identify main case subassemblies. a. Crankcase cover b. Sunys c. Bearing surfaces 8. Proper disassembly procedures. 9. Keeping assemblies together because of wear relationships on each assembly or subassembly.	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Locating model and serial numbers. 2. Cross referencing part numbers from different engine manafactures.	1. Review (or introduce) the purposes for and methods of developing an outline. 2. Outlines of procedures for charts or posters in the shop.	1. Significance of organization for efficient performance. 2. Interdependence among men within an organization.
1. Planing sufficient time for the job.	1. Development of procedural outlines from manuals. 2. Development of outlines from which articles (or speeches may be developed.	1. Evolution of internal combustion engines. How did the evolution depend upon a sequence of inventions over a period of time?
1. Arrangement and numbering of components. 2. Importance of parts fitting together. 3. Use of *Flat Rate Manual* as a guide for determining time required for disassembly.	2. Development pertinent talks or demonstrations to other trainees or fellow workers. 2. Identifying proper component terminology.	1. Competition in the automotive trades. 2. Effect of availability of human resources on the development of additional automotive corporations.

III. APPLICATION

A. An engine will be disassembled to facilitate the study of each component. This will give the student an overview of the necessity of understanding the systems.

B. The student should disassemble the engine to introduce him to the manuals. It will be brought to his attention the disassembly cannot be properly accomplished (without damage) unless he follows the directions.

C. Students should investigate each item as it is removed and identify the location of parts. A sketch of the part location should be made before the item is removed to facilitate the proper replacement.

IV. EVALUATION CRITERIA GUIDELINE

A. How to locate specifications in the manuals.

B. What are recommended procedures for engine disassembly?

C. Identify major engine components by name.

D. What special tools are needed for engine disassembly?

V. SUMMARY

Review use of specifications and repair manuals, preparation for engine dis- 20 minutes . . . Show film: **ABC of Internal Combustion** and discuss film. assemblies and component nomenclature.

VI. SUGGESTED TIME and SEQUENCE LISTING

20 minutes . . . Show film: **ABC of Internal Combustion** and discuss film.

160 minutes . . . Laboratory experiences in engine disassembly and component identification.

180 minutes . . . Related discussions in science, math, communications and social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) **Automotive Engine Test Code.** Detroit: General Motors Corporation (Booklet).

2) Bumphrey, Geoffrey, **Engines and How They Work.** New York: Franklin Watts, Inc., 1960.

3) Crouse, William H., **Automotive Mechanics.** New York: McGraw-Hill Book Company, Inc., 1965.

4) **Diesel: The Modern Power.** Detroit: General Motors Corporation (Booklet).

5) **Engines.** New York: Golden Press, Inc., 1966.

6) Epstein, Samuel and Beryl, **All About Engines and Power.** New York: Random House, Inc., 1962.

7) Meyer, Jerome S., **Engines.** New York: The World Publishing Company, 1962.

8) **Power Goes to Work.** Detroit: General Motors Corporation (Booklet).

9) Roberson, Paul, **Engines.** New York: The John Day Company, 1965.

10) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia.** Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

11) **Transportation Progress.** Detroit: General Motors Corporation (Booklet).

12) Venk, Earnest A. and Billiet, Walter E., **Automotive Fundamentals.** Chicago: American Technical Society, 1961.

13) Wyler, Rose and Ames, Gerald, **What Makes It Go?**, New York: McGraw-Hill Book Company, Inc., 1958.

INSTRUCTOR'S UNIT PLAN

Unit 6
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Valve System Operation**

AIM:

Development of proper vocabulary for valve arrangements and engine identification due to valve arrangements.

Development of student identification of the types of valves and their utilization within the engine.

Development of the student's ability to remove, inspect, repair and replace components of the engine valve system.

INSTRUCTIONAL AIDS:

Slides, 35 mm - **Small Gasoline Engines**, Milwaukee 53201: Briggs & Stratton Corporation.

Slides, 35 mm - (Set No. 4, 12 slides) **How to Inspect and Reface Valves and Seats**, Milwaukee 53201: Briggs & Stratton Corporation.

Transparencies - **#6 Valve Opening and Closing**, Philadelphia: DCA Educational Products, Inc., 1965.

Sample valves for grinding.

EQUIPMENT:

35 mm slide projector, screen, engines that students can disassemble.

Special tool kit for valves (See **Briggs & Stratton Repair Instructions III and Supplement** to select proper tools required for the engine being used for instructional purposes). Valve and valve seat grinding machine (Black and Decker or equivalent). Micrometers (inside and outside) capable of measuring 0-2 inches. Rules (steel, 6" with slide to measure depth). Hand tool kits.

PRIMARY REFERENCES:

1) **Briggs and Stratton Repair Instructions III and Supplement**, Milwaukee 53201: Briggs & Stratton Corporation.

2) Long, Kenneth, **Small Engines Service Manual**, 1014 Wyandotte Street, Kansas City, Mo. 64105: Technical Publications, Inc.

3) Purvis, Jud, **All About Small Gas Engines**, Chicago: The Goodheart-Willcox Company, Inc., 1960.

I. INTRODUCTION and MOTIVATION

A. A valve arrangement of some type is present in every internal combustion engine.

B. This is one of the most common problems and repair jobs performed.

C. The term "valve" sounds simple but it is a complex and hard working component of the engine, particulary in small engines where valves are the most critical component.

D. Use slides to develop discussion and questions.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Valve and cylinder arrangements.	1. Cylinder location. 2. Determines a. Designation of engine types 1) F-Head 2) I-Head 3) L-Head 4) T-Head b. Combustion chamber design	1. Fluids (Gases). a. In combination liquids and air (humidity) 1) Ability to remain mixed 2) Effects of heat and cold on mixtures b. Effect of turbulence c. Flow friction due to directing tube or similar device 2. Vacuum and partial vacuums. a. How obtained b. Fluid (Gases) action 3. Pressure a. How obtained b. Fluid (Gases) action
B. Types of valves. 1. Sleeve 2. Rotary 3. Slide 4. Reed 5. Poppet	1. Valve types and their operation.	1. Cooling a. Air b. Excess air in a fuel air mixture c. Excess fuel in a fuel air mixture 2. How tension and torsion are developed. a. Meaning of each b. Surface tension of flowing gases or liquids. 3. Atmospheric pressure and cooling.
C. Valve operation. 1. Conditions 2. Types 3. Poppet 4. Springs 5. Retainers 6. Toppets 7. Seats 8. Adjustment	1. Conditions under which the valves operate. a. Speed b. Temperature 1) Solid stem 2) Liquid filled stem c. Temperature dissipation 2. Other types of valves. 3. Why the poppet valve is commonly used. a. Simple construction b. Reliable c. Differences (intake and exhaust) d. Nomenclature of the valve 1) Stem 2) Margin 3) Valve face 4) Face angle e. Reconditioning and/or replacement	1. How a certain metal is compounded. 2. Why compound metals are used. 3. Reaction of metals to heat and cold. 4. Examples of a. Soft bearings (babbit) b. Harder bearings bronze brass, etc.) 5. Sealing combustion forces. a. Purpose of rings and lubricant b. Effect of engine wear on compression.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Gear ratios. 2. Valve to crankshaft ratio. 3. Valve tolerance in manufacture.	1. Develop the understanding that word definition vary according to the content in which they are used. 2. Research to develop sereral word meanings for: a. Sleeve b. Rotary c. Slide d. Reed e. Poppet f. Spring g. Seat h. Retainer i. Vacuum j. Stem k. Margin	1. Influence of valve and cylinder design on engine popularity. 2. Influence of advertising on the prospective consumer.
1. Restriction a. Computation of possible flow of fluid (aid) through a restriction b. Combination of restriction-pressure reduction 2. Clearances needed on different types of valves.	1. Identify proper valve nomenclature. 2. Sketching valve assemblies as a supportive visual aid. 3. Valve specification charts.	1. World wide sources of materials required to manufacture parts 2. How removal of present gasoline engine could effect economy of the United States.
1. Operational clearances. 2. Adjusting valves to specs. 3. Seat clearances. 4. Measurement: a. Use of gauges and other measuring instruments. b. Mathematical operations with decimals.		1. Occupations related to the manufacture of engines. a. Technician level b. Skilled level c. Semi-skilled level d. Unskilled level 2. Social implications related to educational opportunities afforded minority groups.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
	4. Valve springs a. Single-multiple b. Testing 1) Specifications 2) Utilize-reject 5. Valve retainers a. Pin b. Collars c. Retainers 6. Toppets a. Cam followers b. Types c. Operation d. Repair and/or replacement 7. Seats a. Block or insert b. Reconditioning c. Replacement 8. Adjustments a. Cold or hot b. Reason for clearance c. Methods	
D. Valve timing and overlap.	1. Engine requirements. 2. Need for timing. 3. Camshafts timing a. Lobes b. Drive connections 1) Chains 2) Gears c. Bearings d. Locations 1) In block 2) Overhead 3) Other e. Repair	1. Loss of power through improper valve overlap 2. Concept of fuel "scavenging."

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Degrees of rotation and overlap.	1. Improve skill in reading diagrams and specfications by interpreting valve overlap diagrams and specfications.	1. "Valveless engines" . . . Topic for research and dicussion in regard to the possible effects on the industry and labor force.

III. APPLICATION

Application wil be an integral part of each technical concept developed. The student should be required to obtain an apprentice level proficiency in the use of special tools and repair procedures, as well as a proficiency in the appropriate technical and idiomatic vocabulary pertaining to each procedure.

IV. EVALUATION CRITERIA GUIDELINE

A. The instructor should evaluate while aiding students in the laboratory situation. Manual combined with knowledge display of utilization of tools, equipment and allowable repairs.

B. Proper vocabulary utilization during discussions, quizzes or requests for parts, equipment or tools.

C. What does valve overlap mean?

D. Why are valves so important in an engine? Particularly a small engine?

V. SUMMARY

A. Review the valve nomenclature and arrangement in engines. Point out the significance of valve timing and overlap for efficient engine performance.

B. Review types of engine cylinder design and valve location in terms of performance and service.

VI. SUGGESTED TIME and SEQUENCE LISTING

45 minutes . . . Present slides on valve operation and service.

135 minutes . . . Laboratory experiences removing, grinding, checking, replacing and adjusting valves.

160 minutes . . . Related concepts.

20 minutes . . . Summary and evaluation.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Ayers, Lewis, **Small Gasoline Engines,** Vol. 7, No. 1, University Park, Pa.: Pennsylvania State University, College of Agriculture, Department of Agriculture Education, 1966.

2) Boumphrey, Geoffrey, **Engines and How They Work,** New York: Franklin Watts, Inc., 1960.

3) **Briggs & Stratton Four-Cycle Air Cooled Engine Repair Instructions,** Milwaukee: Briggs & Stratton Corporation.

4) **Engines,** New York: Golden Press, Inc., 1966.

5) Epstein, Samuel and Beryl, **All About Engines and Power,** New York: Random House, Inc., 1962.

6) Glenn, Harold T., **Exploring Power Mechanics,** Peoria, Ill.: Charles A. Bennett Company, Inc., 1962.

7) Meyer, Jerome S., **Engines,** New York: The World Publishing Company, 1962.

8) Pipe, Ted, **Care and Repair of Your Small Gasoline Engine,** New Augusta, Ind.: Editors and Engineers Ltd.

9) Pipe, Ted, **Small Gasoline Engines Training Manual,** New York: The Howard W. Sams Company, Inc., 1967.

10) Roberson, Paul, **Engines,** New York: The John Day Company, 1965.

11) Rosskopf, Myron F., **Modern Mathematics for Jr. High School,** Morris-

town, New Jersey: Silver Burdett Company, 1961.

12) Stephenson, George, **Power Technology**, Albany, New York: Delmar Publishers, Inc., 1969.

13) Stephenson, George, **Small Gasoline Engines**, Albany, New York: Delmar Publishers, Inc., 1964.

14) Zim, Herbert S., **What's Inside of Engines?**, New York: William Morrow and Company, Inc., Publishers, 1953.

INSTRUCTOR'S UNIT PLAN

Unit 7
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: **Magneto Ignition System**

SUBJECT: SMALL POWER SOURCES

AIM: To develop: (1) an understanding of the basic theory of magneto construction, maintenance and operation; (2) an understanding of the theory and operation of the points, condenser, spark plug and necessary wiring; (3) the vocabulary of the ignition units and associated special tools; and (4) the manual dexterity required for the utilization of the tools and equipment used to service magneto systems.

INSTRUCTIONAL AIDS:

Ignition system components, models and charts.

Film - **Principles of Operation of the Automotive Magneto,** Chicago: United World Films, Inc., 605 West Washington Building (Purchase, 14 minutes, 16 mm).

Film - **How Magnets Produce Electricity,** Chicago: United World Films, Inc., 605 West Washington Building (Purchase, 14 minutes, 16 mm).

Film - **Magnetism,** Temple, Arizona: Arizona State University, Film Cooperative (Rental, 10 minutes, 16 mm).

Film - **Magnets,** Temple, Arizona: Arizona State University, Young America Films, Inc. (Rental, 13 minutes, 16 mm).

Film - **Making Electricity,** Temple, Arizona: Arizona State University, Encyclopaedia Britannica Films (Rental, 11 minutes, 16 mm).

Film - **Power Unlimited,** Temple, Arizona: Arizona State University, Handel Film Corporation (Rental, 13 minutes, 16 mm).

Film - **What is Electricity?,** Pittsburgh, Pennsylvania: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 20 minutes, 16 mm).
Special tools as required for the electrical system.

Wall Charts, MS-4602 - 20"x24", Milwaukee: Briggs & Stratton Corporation.

EQUIPMENT:

16 mm projector, screen, student's engines and special tools and test equipment for the students at their work stations.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement,** Milwaukee 53201: Briggs & Stratton Corporation.

2) **General Theories of Operation,** Milwaukee 53201: Briggs & Stratton Corp.

3) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., 1960.

I. INTRODUCTION and MOTIVATION

A. Small engines normally have magneto type ignition systems.

B. Large number of failures due to ignition system.

C. (Selected previewed film or display) Discussion of small engine systems.

II. PRESENTATION of INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Magnets. 1. Types: a. Flywheel b. Magneto (Dynamos) c. Rotating coils d. Rotor 2. Purpose of the magneto	1. Advanage of small engine having magnets. a. Permanent magnet rotatino by coil of wire b. Coil of wire rotates by a premanent magnet c. Current generation thru revolving and armature within a magnetic field d. Armature arms with rotating magnets.	1. Magnetic field within atoms. a. How the magnetic field can be altered. 2. Magnetic field within metals. a. How they can be altered. b. Effect of Lamination upon magnetic fields.
B. Magneto ignition system basic parts. 1. Breaker cam 2. Breaker points. 3. Condenser 4. High tension coil 5. Laminated iron core 6. Permanent magnets 7. Spark plug 8. High tension wiring	1. Function of components and timing to engine. a. Permanent magnet rotation by a coil of wire b. Primary to secondary induction cycle c. Soft iron core 1) Strengthens magnetic field 2) Reduces eddy currents d. Circuit opening 1) Points 2) Condenser a) Action b) Need e. Breaker cam 1) Action f. High tension circuit and wiring g. Spark plug 1) Construction 2) Action	1. How electrical current can be generated. a. Based on atom and magnetic fields b. Electron movement within a wire c. Induction of electrical current d. Action of magnetic field upon coil of wire e. Factors of generation 1) Magnetic field strength 2) Number of conductors 3) Conductor cutting flux lines speed (rate of motion)
C. Complete magneto-ignition cycle	1. Parts integration to produce spark for ignition.	1. Electrical inertia. a. Time delay consideration b. Arc development consideration

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Ohm's Law a. Practical application 1) Formulas 2) Factors affecting	1. Develop in rough draft from the section necessary for owners manual explaining the ignition system. 2. Exchange materials and develop a written evaluation of the strengths and weaknesses of your partner's material. 3. Revise your own material based on the written evaluation.	1. Electrical generation for consumption of all. a. Location by methods of generation 1) Water 2) Steam 3) Atomic fuel (steam)
1. Ratios. a. Compression b. Effective pressures 1) Change due to point of development	1. Compoents. a. Each should be explained in language that will communicate its meaning to the layman (customer?) 1) Points 2) Condenser 3) Coil 4) Plug 5) General operative factors 2. Practice explaining to the class what is wrong with a hypothetical engine without using technical terms or by explaining each technical term used.	1. Largest generation plants locations. a. Factors affecting location b. Areas where plants might be located but are not c. Effect upon the civilization 1) Developed 2) Undeveloped
1. Electrical power a. Identification 1) Watt, kilowatt 2) How used 3) Formula	1. Communication skills. a. Punctuation b. Structure c. Tense d. Outline forms	1. Electrical power. a. Largest users 1) Industry 2) People b. Transmission 1) Areas where no natural resources are available to generate 2) Areas where natural resources are availible 2. Need for increased availability due to: a. Increasing population b. Effect of wealth on consumption of labor-saving devices.

II. PRESENTATION of INTEGRATED CONCEPTS

	RELATED CONCEPTS	
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
D. Spark advance 1. Automatic 2. Manual	1. Advances a. Automatic 1) Centrifugal force 2) Weights b. Manual 1) Direct connection 2) Need to have inticator or stop	1. Electrical-fuel action a. Fuel burns, not explodes (difference only a time difference) b. Flame front movement c. Difference in burning due to compression d. Ignition point change to produce maximum pressure
E. Impluse coupling.	1. Impulse coupling. a. Need b. Operation	
F. Engine timing.	1. How accomplished. a. Marks or other requirements b. Spark plug function within the timing cycle	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES

III. APPLICATION

A. Students should be required to identify each component of engine systems on his engine.
   1) Magneto.
   2) Timing method.
   3) Keyway and keys.

B. Correct timing of total system.

C. Complete worksheet.

IV. EVALUATION CRITERIA GUIDELINE

A. Practical examination:
   1) Time engine.
   2) Adjustment of points.
   3) Replacement of ignition components.

B. Questions concerning troubleshooting.

V. SUMMARY

A. Components.

B. Method of electrical generation.

C. Timing for proper operation.
   1) Advance-retard.
   2) Impulse coupling within the system.

VI. SUGGESTED TIME and SEQUENCE LISTING

60 minutes . . . Science.

60 minutes . . . Social studies.

60 minutes . . . Math.

120 minutes . . . Instructional topics and technical concepts.

60 minutes . . . Communications.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Duffy, Joseph W., **Power: Prime Mover of Technology.** Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

2) Mileaf, Harry, Editor-In-Chief, **Electricity One-Seven.** New York: Hayden Book Company, Inc., 1966.

3) **Small Engines Service Manual.** Kansas City, Mo. 64105: Technical Publications, Inc., 1014 Wyandotte Street, 1965.

4) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia.** Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

INSTRUCTOR'S UNIT PLAN

Unit 8
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Electrical and Accessory Systems**

AIM: To make the students aware of units that could be attached as a part of the basic engine, such as electrical power sources or other accessory items. To have the student understand that the magneto area could also contain a generator type of unit.

INSTRUCTIONAL AIDS:

Film - **Commutation of DC Machines,** Pittsburgh, Pa.: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 24 minutes, 16 mm).

Film - **Power to Plan,** Pittsburgh, Pa.: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 20 minutes, 16 mm).

Film - **Principles of Generator, The,** San Francisco, Calif.: Photo and Sound Company, 116 Natoma Street (Purchase, 1 reel, 16 mm).

Film - **Principles of Operation of the Generator Regulator,** Chicago, Ill.: United World Films, Inc., 605 West Washington Building (Purchase, 13 minutes, 16 mm).

Film - **Story of Storage Battery,** Cleveland, Ohio: Willard Storage Battery Division, 246-286 E. 131st Street (Free, 32 minutes, 16 mm).

Film - **Story of Storage Batteries,** Pittsburgh, Pa.: Bureau of Mines, United States, Central Experimental Station, 4800 Forbes Street (Rental, 30 minutes, 16 mm).

Film - **AB Circuit Breakers,** Pittsburgh, Pa.: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 10 minutes, 16 mm).

Film - **Charging Storage Batteries,** Chicago, Ill.: United World Films, Inc., 605 West Washington Building (Purchase, 16 minutes, 16 mm).

Film - **Electricity,** Fort Worth, Texas: Charles Pacey, 3601 London Lane (Purchase, 10 minutes, 16 mm).

Film - **What is Electricity?,** Pittsburgh, Pa.: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 20 minutes, 16 mm).

Phamplet - **Battery Service Manual by Willard,** Cleveland, Ohio: Willard Storage Battery Division, 246-286 E. 131st Street (Free).

EQUIPMENT:

16 mm projector, screen, D. C. Generators (both flywheel and self-contained type), necessary special tools and test equipment, ohmmeter, growler and mica undercutter. Necessary tools for disassembly, storage battery, hydrometer and high rate discharge testers. V drive belts (as used on small engine drives or auto fan drives), pulleys, 12 and 110 volt starters for small engines.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement**, Milwaukee: Briggs & Stratton Corporation.

2) Crouse, William H., **Automotive Electrical Equipment**, New York: McGraw-Hill Book Company, Inc., 1955.

3) Mileaf, Harry, Editor-In-Chief, **Electricity One-Seven**, New York: Hayden Book Company, Inc., 1966.

4) Purvis, Jud, **All About Small Gas Engines**, Chicago: The Goodheart-Willcox Company, Inc., Publishers, 1956.

I. INTRODUCTION and MOTIVATION

A. Develop key points of topic through use of selected film.

B. Guide student discussion with facts presented in the film.

C. Outline the different characteristics of engines and their production of electrical current for external use.

D. Stress the fact that many accessories can be delivered as part of the power plant.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Generators. 1. Flywheel 2. Self-contained	1. Generator. a. Basic principles b. Operation 1) D.C. Generator 2) Alternator c. Power utilization d. Drive methods e. Service	1. Metal and acids. a. Reaction of metals to acid attack 1) Different metals affected differently 2) Absorb and change of basic metal b. Sulfuric acid 1) Bases neutralize acids 2) Specific gravity 3) Method of specific gravity reduction
B. Battery.	1. Battery. a. Construction b. Operation c. Testing d. Servicing	1. Electrical properties of acid-metal combinations. a. Change of potential b. Method of restoring balance of metal-acid combination battery c. Wet cell compared with dry cell battery. d. Chemical reaction to produce potential difference and current flow.
C. Regulation. 1. D.C. System 2. Alternator system	1. Regulation. a. D.C. System 1) How accomplished 2) Unit construction of regulator 3) Regulator service 4) Regulator checking b. Alternator system 1) How accomplished 2) Unit construction of regulator 3) Regulator service 4) Regulator checking	1. Recharge cycle can be only with direct current. a. Positive plate b. Negative plate c. Change during discharge cycle d. Change during charge cycle
D. Starters. 1. 12 volt 2. 110 volt	1. Starter. a. Nicad system 1) Battery a) Construction b) Operation c) Charging d) Testing	1. Magnetic fields a. Attraction b. Repulsion c. Field action in coil and wire combination to cause rotation d. Sketches of magnetic fields around attracting and repelling magnets

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Units of measurement. a. Mils for measure b. Computations using the mil as basic unit c. Using tables of wiring characteristics design coils to produce certain magnetic strengths	1. Owners manual. a. Produce sections 1) Generator 2) Battery 3) Regulator 4) Starter 5) External accessories b. Begin special tools section	1. Which nation would profit most if it had generators to install? a. Factors to consider b. How could money be obtained? c. How could the necessary knowledge be obtained? 2. How might this affect the balance of power in the world.
1. Hydrometer. a. Design a hydrometer for testing a (fluid-acid or fluid-oil) mixture b. Effect of mixtures of varying density on hydrometer readings.	1. Select students to: a. Write to company for: 1) Battery literature 2) Generator and/or starter literature b. The step-by-step correct procedure for use of: 1) The hydrometer 2) High rate discharge tester 3) Ammeter 4) Voltmeter 5) Portable tachometer	1. What changes would electrification of a nation bring? a. Urban b. Suburban
1. Determine the ampere rating of a battery (Select a known battery). a. Design test equipment b. Determine rating		1. What changes in social life of the nation would electrification bring? Advantages and disadvantages. a. Urban b. Suburban
1. Torque. a. What it is b. How determined? c. Formula application		1. Under what conditions might it be desirable for a nation not to install generators. a. Pro b. Con

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
SCIENCE	TECHNICAL CONCEPTS	INSTRUCTIONAL TOPICS
	2) Starter a) Construction b) Operation c) Testing d) Service b. 12 volt D.C. System 1) Battery a) Size b) Testing c) Service 2) Starter a) Operation b) Service c. 110 volt system 1) Rectifier assembly a) Operation b) Testing c) Service 2) Starter assembly a) Operation b) Testing c) Service	
E. Other units. 1. Pumps 2. Blowers 3. Miscellaneous	1. Other units. a. Pumps 1) Oil (hydraulic) 2) Air 3) Water b. Blowers 1) Centrifugal 2) Piston c. Miscellaneous 1) Fuel pump 2) Drive pulleys for units 3) Direct drive for unit movement	1. Fluids. a. Non-compressible b. Transfer of forces within the fluid c. Work accomplishment with fluids
F. Special tools	1. Special tools/equipment should be introduced and instructed upon as the lesson requires their use.	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Fluids. a. Reinforce area, volume formulas b. Power transfer through fluids on areas		

III. APPLICATION

A. Student should disassemble and assemble generators and starters.

B. Student should test battery with hydrometer and high rate discharge tester (or similar equipment).

C. Student should remove cover from and identify units of the regulator.

D. Student should test one of the three types of starters covered in this lesson.

E. Student should construct five test questions on the lesson subject matter.

IV. EVALUATION CRITERIA GUIDELINE

From the questions submitted by the class, a suitable test will be constructed. Practical examinations should be conducted.

V. SUMMARY

Review the function, operation and service of the followin:

A. Generators.

B. Battery.
   1) Testing
   2) Servicing

C. Generator output regulation.

D. Starters, types and testing.

E. Accessory units.

F. Special tools.

VI. SUGGESTED TIME and SEQUENCE LISTING

60 minutes . . . Science.

45 minutes . . . Math.

180 minutes . . . Instructional topics and technical concepts.

40 minutes . . . Communications.

35 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Barnard, J. Darrell, **Science: Key to the Future**, New York: The Macmillan Company, Publishers, 1962.

2) Blackwood, Paul E., **Push and Pull: The Story of Energy**, New York: McGraw-Hill Book Company, Inc., 1959.

3) Posin, Daniel Q., **What Is Energy?**, Chicago: Beckley-Cardy Company, 1968.

4) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia**, Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

INSTRUCTOR'S UNIT PLAN

Unit 9
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Fuel and Governor Systems**

AIM: To have the student develop an understanding of the operation and function of small engine fuel and governor systems including their maintenance, repair and adjustment.

INSTRUCTIONAL AIDS:

Carburetors from student engines.

Carburetor manual for each student work station.

Film - **ABC of Internal Combustion.** General Motors Corporation, Educational Relations Department, Department of Public Relations, Box 177, North End Station, Detroit: (Free, 13 minutes, 16 mm).

Film - **Carburetor Principles of Operation.** United World Films, Inc., 605 West Washington Building, Chicago: (Purchase, 25 minutes, 16 mm).

Film - **Down the Gasoline Trail.** Jam Handy, 281 E. Grand Blvd , Detroit: (Purchase, 11 minutes, 16 mm).

EQUIPMENT:

Special tools required for carburetor disassembly- assembly, replacement parts, carburetor cleaning solvent, testing equipment as required, 16 mm projector and screen.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Suppliment.** Milwaukee: Briggs & Stratton Corporation.

2) **General Theories of Operation.** Milwaukee: Briggs & Stratton Corporation.

3) Long, Kenneth, Editor, **Small Engines Service Manual.** Kansas City, Mo. 64105: Technical Publications, Inc., 1966.

4) Purvis, Jud, **All About Small Gas Engines.** Chicago: The Goodheart-Willcox Company, Inc., 1960.

I. INTRODUCTION and MOTIVATION

A. Preview (selected) film. Alert students to the main concepts of film.

B. Display carburetors of different types, some with and some without integral fuel pumps.

C. Display parts which normally make up a small engine governor.

D. Explanation of two units operating together.

II. PRESENTATION of INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Fuel system. 1. Function 2. Rating by octane 3. Gasoline 4. Combustion 5. System operation a. Venturi b. Atomspheric pressure	1. System. a. Stores b. Routes c. Vaporized mixture d. Combustion 1) Pressure 2) Gas resultant e. Atmosphere 1) Pressure 2) Reaction to partial vacuum	1. Fuel ratings. a. Octane 1) Anti-knock quality 2) Percent of isoheptane rated against heptane 3) Develop content of these two liquids b. Crude oil cracking in refinery 1) Heat at which each component of crude oil will separate 2) Percentage of fuels usable in internal combustion engine
B. Components of fuel system. 1. Storage tank 2. Distribution systems 3. Pumps 4. Strainer (fuel) 5. Choke system (priming system) 6. Air cleaner 7. Governor	1. Storage tank is fuel reservoir. 2. Distribution. a. Lines b. Manifolds 3. Pumps. a. Pressure or vacuum operated b. Mechanical c. Hand (priming) 4. Strainer (fuel) a. Action b. Micron selection 5. Choke system. a. Manual priming b. Manual butterfly c. Automatic 6. Air cleaner. a. Construction b. Purpose c. Replacement . . . cleaning 7. Governor. a. Operation b. Carburetor relationship, operation of butterfly by the governor c. Maintenance of selected R.P.M. and prevents surging	1. Atmospheric-vacuum pressures interaction. a. Sea level pressure b. Measure 1) Pounds per square inch 2) Inches of mercury 3) Isobar c. Effect when flow through venturi d. Utilization of low pressure area of venturi
C. Carburetor principles of operation. 1. Partial vacuum 2. Atmospheric pressure 3. Air cleaner	1. Valves closed downward motion or piston creates partial vacuum. 2. Atmospheric pressure flows from high into this low pressure area. 3. Carburetor acts as scale and measures necessary correct amount.	1. Pollution in atmosphere. a. How suspended b. Types 1) Liquids 2) Gases 3) Solids

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Measure of atmospheric weight. a. Atmospheric weight against a known area as internal vacuum is reduced b. Effects of altitude and temperature on atmospheric weight.	1. Prepare carburetion section of owners manual.	1. Study of the search for oil. a. How conducted b. By whom conducted 2. Location of world's major oil deposits.
1. Cross-section area of venturi. a. Square measurement b. Effect upon air flow c. Calculation of negative pressures.	1. Begin development of worksheets and assignment sheets for each unit.	1. Oil and natural gas transportation within the United States.
1. Lifting ability of vacuums created by venturi action.		1. Foreign crude oil. a. How transported to the U. S. b. Effect upon American oil business c. Effect upon international relations.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
	4. Carburetor mixes air with vaporized fuel. 5. Air cleaner traps dirt particles to prevent internal damage.	4) Effect of unfiltered ingestion into engine c. Filtering methods 1) Water 2) Electrostatic 3) Paper and foam types d. Effects on combustion
D. Carburetor components. 1. Float and float bowl 2. Jets 3. Venturi 4. Throttle valve 5. Choke valve 6. Idle valve 7. Needle valve	1. Float and float bowl operate at a constant fuel supply level. 2. Jets are metering devices. 3. Venturi section produces low pressure needed for operation. 4. Throttle valve controls speed of engine by air flow control. 5. Choke valve also controls air flow inlet. 6. Idle valve adjusts and controls gasoline at low speeds. 7. Needle valve controls gasoline amount flow.	
E. Carburetor types.	1. Gravity flow. 2. Atmospheric pressure flow. 3. Updraft, downdraft difference of identification.	1. Internal combustion engine contribution to the pollution. a. Recent modifications intended to reduce pollutants. b. Legislative efforts to reduce pollutants. c. How proper adjustments reduce pollution level. d. How various additives such as lead increase danger. 2. Increased public awareness of pollution problem.
F. Carburetor teardown. 1. Inspect parts 2. Test against specifications 3. Reassemble	1. Follow visual check procedures. 2. Utilize special tools to check components of the carburetor. 3. Assemble following specifications set forth in the manual.	
G. Carburetor adjustments.	1. Adjustments availible. 2. Reason for adjustments. a. Economy b. Smoothness c. Efficiency	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Fuel-air ratios. a. By weight b. By volume c. Comparsion of ratio using numerical and graphic representations.		
		1. Social and economic implications of pollution upon a society so dependent on the internal combustion

III. APPLICATION

A. Disassemble carburetor, inspect and test parts.

B. Replace defective parts.

C. Assemble carburetor using correct procedures as outlined in manual.

D. Student-developed worksheets and assignment sheets (developed in communications class, should be utilized as a test both of the development of them and their use for student direction).

IV. EVALUATION CRITERIA GUIDELINE

A. What is the purpose of a venturi?

B. Demonstrate how float measurements and adjustments are made.

C. What test instruments are needed to analyze and adjust a carburetor?

D. Practical work should be utilized for testeing in all possible cases.

V. SUMMARY

Review characteristics and service highlights of the following:

A. Fuel system.
B. Components.
C. Principles of operation.
D. Carburetor components.
E. Carburetor types.
F. Carburetor disassembly-assembly.

VI. SUGGESTED TIME and SEQUENCE LISTING

45 minutes . . . Science.

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Math

45 minutes . . . Social studies.

45 minutes . . . Communications.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Crouse, William H., **Automotive Mechanics.** New York: McGraw-Hill Book Company, Inc., 1965.

2) Dolciani, Mary P., **Modern Algebra: Structure and Method.** Boston: Houghton Mifflin Company, 1965.

3) Rogers, Eric M., **Physics for the Inquiring Mind.** Princeton, New Jersey: Princeton University Press, 1960.

4) Stephenson, George E., **Power Mechanics.** Albany, New York: Delmar Publishers, Inc., 1963.

5) Stephenson, George E., **Small Gasoline Engines,** Albany, New York: Delmar Publishers, Inc., 1964.

6) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia.** Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

INSTRUCTOR'S UNIT PLAN

Unit 10
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Lubrication and Cooling Systems**

AIM: To develop the student's understanding of:

A. Lubricating oils.
B. Distribution methods of lubricants.
C. Engine cooling by both lubricants and other means.

INSTRUCTIONAL AIDS:

Charts, illustrations and models of refineries, oil wells or oil fields, assorted oil pumps and oils and greases.

Film - **Basic Principles of Lubrication,** General Motors Corporation, Educational Relations Department, Department of Public Relations, Box 177, North End Station, Detroit: (Free, 25 minutes, 16 mm).

Film - **Oil Films In Action.** General Motors Corporation, Educational Relations Department, Department of Public Relations, Box 177, North End Station, Detroit: (Free, 16 minutes, 16 mm).

Film - **Ten Thousand Feet Deep,** Shell Oil Company, Public Relations Department, 50 West 50th Street, New York: (Rental, 20 minutes, 16 mm).

Film - **Frontiers of Friction,** Shell Film Library, 450 Meridian Street, Indianapolis, Ind.: (Rental, 18 minutes, 16 mm).

EQUIPMENT:

16 mm projector, screen, bunsen burner and vicosimeter, shell and poured type of bearings with crankshaft, plastigage and a variety of engine lubricants.

PRIMARY REFERENCES:

1) Bernard, J. Darrell, **Science: A Key to the Future,** New York: The Macmillan Company, Publishers, 1962.

2) **Briggs & Stratton Repair Instructions III and Supplement,** Milwaukee: Briggs & Stratton Corporation.

3) Duffy, Joseph W., **Power: Prime Mover of Technology,** Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

4) Long, Kenneth, **Small Engines Service Manual,** Kansas City, Mo.: Technical Publications, Inc., 1966.

5) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart- Willcox Company, Inc., 1960.

I. INTRODUCTION and MOTIVATION

A. Preview (selected) film. Emphasize points of special interest.

B. Discussion having students develop need for and action of lubrication and cooling system.

C. Discuss need for oil in its three states for different lubrication jobs.

D. Discuss need for lubricants other than lubricating oil that are extracted from crude oil.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Purpose of oil in an engine	1. Provide an anti-friction film between parts.	1. Review production of refinery. a. Base of oil b. Relationship to heat of separation from crude.
B. Function of oil. 1. Cleans 2. Cooling 3. Cushions 4. Sealer 5. Rust preventative	1. Suspends particles until settles. 2. Heat transfer characteristics. 3. Film separates wear surfaces. 4. Seals (as at rings) as it lubricates. 5. Prevents oxidation.	1. Test for anti-friction characteristics and ability.
C. Lubrication oils classification. 1. Service classifications MC, MM, MS 2. Type M and D 3. Viscosity 4. Multigrade oils 5. Detergent oils	1. Lubricating oils classified by: a. Type b. Quality c. Viscosity 2. Characteristics of multigrade lubricants. 3. Detergent oil suspension ability.	1. Perform viscosimeter test.
D. Lubrication methods. 1. Splash 2. Constant level splash 3. Ejection pump 4. Barrel-type pump 5. Full pressure pump system 6. Two-cycle lubrication	1. Lubricate moving parts surfaces to prevent wear and failure. 2. Constant supply necessary. 3. Two-cycle. a. Mix oil-fuel b. Internal flow of suspended oil	1. Observe action of dirt particles in oil. a. Blow dust slowly across oil surface. b. Check bottom after allowing time for settling. c. Perform test with oil static and oil being vibrated.
E. Need for cooling.	1. Prevent build-up of heat to point of destruction. 2. Selected operating temperature maintenance.	1. Apply heat to different metals. a. Heat to low temperatures. b. Heat to high (destruct) temperature.
F. Small engine cooling. 1. Fins 2. Flywheel blower 3. Air directed by shrouds 4. System maintenance	1. Fins utilized to increase heat radiating surface. 2. Flywheel blower source of air. 3. Shrouds direct the cooling air. 4. Maintenance. a. Flywheel balance b. Shrouds in place c. Clean	1. Thermal conductivity of air. a. Stagnant b. Moving

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Computation of area. a. Review of prior study b. Uneven surface (ribs and grooves). c. With incomplete surfaces	1. Owners manual section on lubrication and cooling.	1. History of oil until invention of internal combustion engine.
1. Centigrade-Fahrenheit scales and formulas. a. Differences b. Where used c. Convert centigrade to Fahrenheit d. Convert Fahrenheit to centigrade	1. Discussion of basic safety concepts and how they apply specifically to this area. 2. Begin Handbook of Safety for shop, tools and specific jobs.	1. Location of first oil well. a. Problems b. Development of industry following
1. Pressure transfer through liquids a. Work b. Against open end c. Calibrated by-pass leakage d. Volume change as in pumps	1. Research reports of how oils: a. Clean b. Lubricate c. Preserve	1. Foreign oil fields. a. Effect on our economy b. Effect on their economy c. Political implications
1. Coefficients. a. Location b. Use in computations c. Application to specific problems	1. Manual section covering maximum damage area repair of cast fins.	1. Resultant effect upon world politics due to oil.
	1. Repair procedures for shrouds.	
	1. Begin design of and production of worksheets and assignments sheets covering small engine.	

II. PRESENTATION of INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
G. Larger engines mostly liquid cooled. 1. Land-type engines a. Radiator b. Liquid pump c. Liquid jacket d. Thermostat e. Fan f. Hoses or plumbing 2. Outboard type a. Pumps 1) Plunger 2) Eccentric rotor 3) Impeller b. System comparison	1. Engine contains jacket about the cylinder. a. Circulation by pump b. Radiator 1) Construction 2) Heat transfer c. Fan 1) Air circulation 2) Drive 2. Liquid circulates from below waterline back to source.	1. Thermal conductivity of liquids. a. Several others b. Fresh and salt water c. Special 2. Calculation of specific heat of liquids and solids. 3. Method used to facilitate heat transfer.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES

III. APPLICATION

Students should identify lubrication and cooling system parts and trace flow patterns. Using plastigage and suitable engine parts, students should check and adjust clearances for oil film.

IV. EVALUATION CRITERIA GUIDELINE

A. Selection of proper lubricant for lubrication situation.

B. Respond to questions concerning single and multigrade oils as well as detergent oils.

C. Describe differences between lubrication systems of two-cycle and four-cycle engines.

V. SUMMARY

A. Purpose and function of oil.

B. Classifications.

C. Lubrication methods.

D. Cooling systems:
   1. Need
   2. Air
   3. Liquid

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minut s . . . Instructional topics and technical concepts.

45 minutes . . . Science

45 minutes . . . Communications

45 minutes . . . Math

45 minutes . . . Social studies

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Dull, Charles E., **Modern Chemistry,** New York: Holt, Rinehart & Winston, Inc., 1960.

2) Meyer, Jerome S., **Engines,** New York: The World Publishing Company, 1962.

3) Roberson, Paul, **Engines,** New York: The John Day Company, 1965.

4) Stephenson, George, **Power Technology,** Albany, New York: Delmar Publishers, Inc., 1968.

5) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia,** Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

INSTRUCTOR'S UNIT PLAN

Unit 11
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Engine Rebuilding and Assembly**

AIM:

A. To develop within the student an ability to: Identify and service components and subassemblies of the small engine being worked with.

B. Students should focus on uses of required special tools, use of measuring equipment and gaining manual dexterity in the handling of parts and equipment.

INSTRUCTIONAL AIDS:

Set No. 1 . . . 68 slides (35 mm - Reassembly section) Complete Overhaul, Briggs & Stratton Corporation, Milwaukee, Wisconsin 53201.

Charts, models and illustrations.

Engines for disassembly and assembly.

EQUIPMENT:

35 mm slide projector, screen, special tools for assembly, precision measuring equipment and plastigage.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement,** Milwaukee: Briggs & Stratton Corporation.

2) **General Theories of Operation,** Milwaukee: Briggs & Stratton Corporation.

3) Long, Kenneth, **Small Engines Service Manual,** Kansas City, Mo.: Technical Publications, Inc., 1966.

4) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., 1960.

I. INTRODUCTION and MOTIVATION

A. Present engine assembly using slides.

B. Highlight points where errors are most likely to occur.

C. Explain special tools and their uses.

D. Discuss importance of clearances and the use of the torque wrench and plastigage.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Assembly. 1. Piston, pin, rod. 2. Rings on piston. 3. Crankshaft, camshaft cam followers. 4. Crankcase cover. 5. Valves, valve springs and retainers. 6. Ignition system. 7. Flywheel. 8. Carburetor and governor. 9. Head. 10. Shroud.	1. Proper use of special tools in all steps. a. Proper fit of piston, pin, and rod b. Proper fit rings to cylinder, rings to piston c. Main journal fit, camshaft fit and timing. Cam followers for fit block and on cam. d. Crankcase cover to main journal fit e. Valve stem to block fit. Install valve springs and retainers. f. Ignition system 1) Condenser 2) Points 3) Cover 4) Sealant 5) Coil 6) High tension lead 7) (Last item) Spark plug (after head is installed) g. Flywheel 1) Key 2) Washer and nut h. Carburetor and governor 1) Interaction devices i. Head 1) Torque 2) Gasket preparation j. Shroud 1) No force 2) Flywheel clearance	1. Characteristics of materials when subject to heat. a. Expansion rates 1) Single 2) In combinations b. Effect of spot cooling
B. Service 1. Oil 2. Fuel	1. Proper a. Weight b. Type c. Amount 2. Proper a. Grade b. Clean	1. Atmospheric aging vs. artificial aging. a. Materials aging when exposed only to air. b. Materials artificially aged.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Volume flow of gases through specific hole sizes. a. Plain pipe b. Poppet valve control	1. Owners manual section for assembly.	1. Devise a hypothetical overhaul shop. a. Stations, receiving to delivery b. How does the position in the shop affect the person's life? 2. Determine an ideal location for the shop. a. Population of area b. Accessibility c. Technical institutes nearby d. Labor force
1. Torque. a. As developed by the engine b. As developed by tool leverage c. Practical applications of torque as applied to engines and tools.	1. Further development on assignments and worksheets for each lesson unit. 2. Letters to manufactures of torque measuring devices for literature suitable for classroom.	1. Skills. a. Availability b. Development 1) Educational requirements 2) Can all be developed c. Attitude of people toward 1) Training 2) Are their attitudes realistic?

II. PRESENTATION of INTEGRATED CONCEPTS

	RELATED CONCEPTS	
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
C. Operation 1. Starting. 2. Carburetor.	1. Starting. a. Fire hazard from flooding b. No fuel links from vibration 2. Carburetion. a. Mixture adjust b. Speed adjust	1. Heat treatment of materials. a. Reason b. Resultant

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Horsepower. a. How derived b. Practical application of formulas c. Brake d. Friction e. Practical application to . . . specific problems.	1. Development of handout materials for explaining how engines are rated for horsepower. 2. Further development of the safety program needed during classroom and laboratory.	1. Equipment necessary. a. Where obtained 1) Raw materials 2) Skills needed to procedure the device 3) Justify need for that equipment b. Power 1) Available in all areas of the world 2) Where could the device not be used? Why? c. Finance 1) Owner 2) Partnership 3) Corporation

III. APPLICATION

A. This lesson is based upon the application of knowledge gained in prior lessons.

B. Caution should be exercised to insure the student uses the skills properly.

IV. EVALUATION CRITERIA GUIDELINE

A. The student should be evaluated throughout the assembly procedure.

B. Practical application of the knowledge gained based tests.

C. Vocabulary identification and explanation of terms.

D. Identification of engine components and related tools and equipment used in rebuilding.

V. SUMMARY

A. Assembly:
   1. Procedures
   2. Special tools
   3. Proper fit

B. Service:
   1. Proper selection
   2. Safety

C. Operation:
   1. Starting
   2. Adjusting

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communications.

45 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Duffy Joseph W., **Power: Prime Mover of Technology**, Bloomingt n, Ill.: McKnight & McKnight Publishing Company, 1965.

2) **Engine Torque Specifications**, P. A. Sturtevant Company, 1957.

3) **Pulling System**, Booklet No. P5-2, Owatonna, Minn. 55060: Tools and Equipment Division, Owatonna Tool Company, 1968.

4) Toboldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia**, Homewood, Ill.: The Goodheart-Willcox Company., Inc., 1965.

INSTRUCTOR'S UNIT PLAN

Unit 12
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Comparative Analysis of Two-Stroke Cycle with Four-Stroke Cycle Engines**

AIM: To have the student develop an understanding of:

A. The differences between two stroke cycle engines and four stroke cycle engines.

B. The requirements that aid in determining the selection of a certain power plant for a particular installation.

INSTRUCTIONAL AIDS:

Four-stroke cycle engines (one per two students).

Two-stroke cycle engines (one per two students).

Charts, models and illustrations.

EQUIPMENT:

Miscellaneous hand tools for partial disassembly of two and four stroke cycle engines by instructor. Tool boxes and special tools for disassembly of two stroke cycle engines.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement**, Milwaukee: Briggs & Stratton Corporation.

2) Long, Kenneth F., **Small Engines Service Manual**, Kansas City, Mo. 64105: Technical Publications, Inc., 1966.

3) Purvis, Jud, **All About Small Gas Engines**, Chicago: The Goodheart-Willcox Company, Inc., 1960.

4) Stephenson, George E., **Small Gasoline Engines**, Albany, New York: Delmar Publishers, Inc., 1964.

I. INTRODUCTION and MOTIVATION

A. Discuss advantages of each engine.

B. Select several applications that show usefulness of each type.

C. Equate each engine type to the use of each student.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Disassemble two stroke cycle and four stroke cycle engine.		1. Friction. a. Cause b. Comparsion of friction amount with different materials in contact.
B. Comparison. 1. External featores. 2. Each system. a. Number of components b. What parts replaced 3. Internal differences. a. Design b. Operational changes	1. Basic likeness. 2. Valves. 3. Pistons. a. Some heads shaped differently b. In cylinder piston performance	1. Reduction of friction. a. Clearances b. Choice of materials c. Lubricants 1) Review in detail analysis of lubricants 2) Liquids . . . semi-liquids
C. Fuel system. 1. Components differences. 2. Operational differences.	1. Reed valve. 2. Law pressure area creation. 3. R. P. M. comparison.	1. Heat dissipation thru metals. 2. Difference in heat dissipation, for two and four-cycle.
D. Ignition system.	1. Different requirements.	1. Fundamentals of electricity. a. Basic concepts b. Electron flow (Begin develop for future application to appliance study). c. Circuits 1) Series 2) Parallel d. Switches e. Resistance
E. Lubrication system.	1. How the two stroke cycle differs. 2. How each area is lubricated.	
F. Cooling system.	1. Requirements. 2. Alikeness.	
G. Weight difference. 1. Per horsepower. 2. Application advantages.	1. Two stroke cycle horsepower/ weight ratio. 2. Four stroke cycle horsepower/ weight ratio. 3. Application. a. Weight requirements b. R.P.M. requirements c. Vibration requirements	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Compression. a. Weight of air b. Change in volume c. Potential storage develope by compression	1. Develop a carburetion section for an owners manual for a two-stroke cycle engine.	1. History of mass media communications.
1. Work. a. Systems design 1) Cylinder . . . piston 2) Turbine b. Non-confined air accomplishing work 1) System design 2) Mechanical linkage i. e.: 3) Specific problems (Design a windmill water pump).	1. Basic study of English composition. a. Vocabulary b. Punctuation c. Spelling d. Sentence structure	1. Methods of producing mass media communications. a. Printing devices b. News gathering
	1. Develop an advertising program for: a. Sale of engines b. Repair shop for engines c. Engine - operated devices showing labor-saving advanages.	1. Social impact of mass media communications. a. Need shaping of population b. Status
	1. Develop an awareness and knowledge of methods of mass communications. a. Newspapers b. Books c. Others	1. Economic impact of mass media communications.
	1. Assignment and worksheet development. Continue to develop for each unit of lesson.	

III. APPLICATION

A. Students will disassemble the two-stroke and four-stroke cycle engines. Parts will be properly identified.

B. The proper choice of hand tools and special tools should be studied during the disassembly.

IV. EVALUATION CRITERIA GUIDELINE

A. Practical application of unit knowledge. Identification of specific tools and/or parts.

B. Reasoning to show knowledge for need of specific components.

C. Identify the basic differences and similarities in two and four stroke cycle engines.

V. SUMMARY

A. Comparison of four-stroke cycle and two-stroke cycles.

B. Differences:
1. Fuel system
2. Lubrication system
3. Ignition system
4. Weight horsepower

C. Application differences

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science

45 minutes . . . Math

45 minutes . . . Communications

45 minutes . . . Social studies

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Barnard, J. Darrell, **Science: Key to the Future**, New York: The Macmillan Company, Publishers, 1962.

2) Crouse, William H., **Automotive Mechanics**, New York: McGraw-Hill Book Company, Inc., 1965.

3) Meyer, Jerome S., **Engines**, New York: The World Publishing Company, 1962.

4) Milgaf, Harry (Editor-In-Chief) **Electricity One-Seven**, New York:Hayden Book Company, 1966.

5) Rogers, Eric M., **Physics for the Inquiring Mind**, Princeton, New Jersey: Princeton University Press, 1960.

6) Stephenson, George, **Small Gasoline Engines**, Albany, New York: Delmar Publishers, Inc., 1964.

INSTRUCTOR'S UNIT PLAN

Unit 13
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Overhaul of Two-Stroke Cycle and Four-Stroke Cycle Engines**

AIM: To further develop the skills required for inspection, repair and overhaul of two-stroke and four-stroke cycle engines.

INSTRUCTIONAL AIDS:

Repair Instructions MS-4750, Milwaukee, Wisconsin 53201: Briggs & Stratton Corporation.

Set No. 1 . . . 68 slides, **Complete Overhaul,** Set No. 2 . . . 27 slides, **Check Up,** Set No. 3 . . . 11 slides, **Resizing Cylinders,** Set No. 4 . . . 12 slides, **Valves and** Seats and Set No. 5 . . . 12 slides, **Bearing Replacement,** all 35 mm and available from Briggs & Stratton Corporation, Milwaukee, Wisconsin, 53201.

Overhaul manual for specific two stroke cycle engine dismantled in Unit 13.

EQUIPMENT:

35 mm slide projector, screen, special tools required by two-stroke cycle engine dismantled in Unit 13, hand tools for students and special equipment for valve seat grinding, cylinder resizing, surface truing for two-stroke cycle and four-stroke cycle comparison.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement,** Milwaukee: Briggs & Stratton Corporation.

2) **General Theories of Operation,** Milwaukee: Briggs & Stratton Corporation.

3) Long, Kenneth F., **Small Engines Service Manual,** Kansas City, Mo. 64105: Technical Publications, Inc., 2014 Wyandotte Street.

4) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., Publishers, 1960.

I. INTRODUCTION and MOTIVATION

A. Comparatively few differences occur between two and four-stroke cycle engines. If the knowledge of overhaul of one is gained then the student should be able to overhaul the other.

B. Present slides noting differences in procedures for servicing.

C. Discuss safety and precautions to assure safe and proper overhaul.

II. PRESENTATION of INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Serviceability. 1. Information source 2. Determination	1. Location of information. a. For tests b. For direction during determination of serviceability 2. Interpret from source to machinery.	1. Other matter used as fuel. a. Structure b. Method of use c. Practical application 2. The atom as fuel. a. How changed to fuel b. Practical application c. Problems d. Characteristics of a good fuel.
B. Measurements. 1. Internal 2. External 3. In combination	1. Inside micrometer and other internal measuring devices. a. Roundness b. Taper 2. External micrometer and other external measuring devices. a. Roundness b. Taper 3. Internal-external fit of connecting parts.	1. Potential power determination for atomic power. a. Energy release b. Energy control c. Safety
C. Clearance fitting. 1. Special tool use 2. Determination 3. Allowable rework	1. Use of scales and other special tools. 2. Practical use of #1 devices. 3. Determination of allowable rework. a. Can item be reworked b. Condition to allow rework	1. By-products of the atom as power. a. Waste matter b. Equipment problems 1) During use 2) After useful life c. Radioactivity d. Thermal pollution
D. Reworking equipment. 1. Valves and seats 2. Connecting rod, pin and piston boss 3. Piston skirt 4. Cylinder 5. Crankshaft 6. Head 7. Cooling system a. Liquid b. Air-cooling fins c. Flywheel 8. Ignition system	1. Reworking of rod, pin, piston combinations. a. Ream b. Pin . . . oversize 2. Rings and ring grooves. 3. Piston. a. Skirt peen b. Ring groove conditioning 4. Reboring. a. Taper b. Within tolerances c. Standard oversizes 5. Regrinding. a. Round b. Within tolerances c. Standard undersize	1. Other lubricants. a. Produced directly from petroleum b. From sources other than petroleum c. Modern application

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Compression ratio. a. Change due to cylinder resizing b. Change due to head milling 2. Formulas. 3. Practical application.	1. Develop sections for owner's manual not completed.	1. History of the development of atomic power. a. Persons b. Places c. Times 2. Testing location. a. Why? b. Distance measure 1) Conventional explosions 2) As applied to new atomic power 3. Use of first atomic power.
1. Measurements. a. Reduction to decimal equivalent b. Reading of decimals	1. Develop assignment and work sheets for this unit. (Note: Units not having assignment or work sheets should be considered at this time).	1. Atomic power today. a. Uses b. Locations c. Natural resources requirements d. Possible effect upon natural ecology e. Social and political implications.
1. Tapers. a. Cones b. Reduction to tapers c. Determine taper by measurement	1. English grammar. a. Usage b. Punctuation c. Spelling	1. Future. a. Applications b. Need for development c. Changes resultant from developments.
1. Torque. a. Practical problems b. By other than internal combustion source	1. Library research. a. For owners manual bibliography b. Resource material for class external reading c. History of development of specific application of internal combustion engine	1. Change in electrical power due to development. a. Availability b. Social . . . economic impart

II. PRESENTATION of INTEGRATED CONCEPTS

	RELATED CONCEPTS	
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
	6. Flat head and block mating surfaces. a. Surface plate or machine head b. Machine block c. Compression ratio change 1) Use caution 2) Compensate 7. Cooling area reduction. a. Fin b. Tube c. Broken fins 1) Clean rough edges 2) Maximum fin area reduction allowable d. Flywheel balance 1) Less air 2) Overheating 8. Magnet strength. a. Coil 1) Open 2) Short b. Points c. Condenser 1) Open 2) Short d. High tension circuit	
E. Fitting rework parts. 1. Information source 2. Methods	1. Tolerances. a. Charts of fitting allowances b. Fitting of new and reworked parts	1. Lubricant testing. a. To reduce friction b. Resist breakdown under different operating conditions c. Research for requirements of atomic equipment 1) Special 2) Conventional
F. Reassembly. 1. Proper tolerances 2. Free movement	1. Free movement. a. Visual checks for excessive movement b. Turning torque	1. Non-mechanical electrical power generators. a. Solar cells b. Fuel cells c. Thermal generators d. Chemical converters
G. Testing and adjusting.	1. Special equipment. a. Use b. Testing	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Graphing factors. a. Introduction to graphing b. Simple problems	1. Safety. a. Further development of manual on safety b. Research for sources concerning First Aid c. Write to Red Cross of infirmary staff for guest speaker.	

III. APPLICATION

The total lesson is to be used to develop proper application of the tools and skills to overhaul and repair small internal combustion engines.

IV. EVALUATION CRITERIA GUIDELINE

A. Observation and control of student's efforts during the rebuilding-repair of the engine.

B. Explanation (by student) of proper procedures for using tools.

C. Observations of students making actual measurements.

V. SUMMARY

Emphasize the following points in a summary:

A. Serviceability.

B. Measurements.

C. Clearance and fitting.

D. Reworking equipment.

E. Fitting reworked or reconditioned parts.

F. Reassembly.

G. Testing and adjusting.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communication.

45 minutes . . . . Social Studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Epstein, Samuel and Beryl, **All About Engines and Power**, New York: Random House, Inc., 1962.

2) Glenn, Harold, **Exploring Power Mechanics**, Peoria, Ill.: Charles A Bennett Company, Inc., 1962.

3) **Go-Power Engine Analysis Systems**, 155 Montgomery St., San Francisco: Go-Power Corporation, 1966.

4) Pipe, Ted, **Care and Repair of Your Small Gasoline Engines**, New Augusta, Ind.: Editors and Engineers, Ltd.

5) Stephenson, George, **Power Mechanics**, Albany, New York: Delmar Publishers, Inc., 1963.

6) Stephenson, George, **Small Gasoline Engines**, Albany, New York: Delmar Publishers, Inc., 1964.

7) Zim, Herbert S., **What's Inside of Engines?**, New York: William Morrow and Company, Inc., Publishers, 1953.

SUGGESTED TOOL LIST for SMALL ENGINE SERVICE

Names ..... Date ...../...../.....

Tool Box Letter .....

DIRECTIONS: Check tools for quantity and letter identification. If tool is accounted for place an X in the space only next to the tool. (Eq. ..... X ..... 8" screwdriver). Tools will be checked at end of each day. You will be responsible for tools which you have lost. Give the sheet back to the instructor so that he can approve it. A lock must be installed on your tool box.

TOOL BOX CONTENTS

Tool Box w/Tray

Screwdrivers
- 8"
- 6"
- 4"

Chisels
- C-24
- C-16

Drift Punches
- P-4
- P-6
- P-8

- Hammer, Ballpein (2-0)
- Speed Wrench-½" Drive
- Speed Wrench-⅜" Drive
- Ratchet - ½" Drive
- Ratchet - ⅜" Drive
- Universal - ½" Drive
- Universal - ⅜" Drive

Extensions
- 10" - ½" Drive
- 5" - ½" Drive
- 10" - ⅜" Drive
- 5" - ⅜" Drive

Pliers
- 6"
- 8"

Interlocking Joint Pliers
- No. 1520 A (Large)
- No. 1519 A (Small)

Wrench - Open End - Box

1"	13/16"	5/8"
7/16"	15/16"	3/4"
9/16"	3/8"	7/8"
11/16"	1/2"	

Wrench - Adjustable - Crescent
- 8"
- 6"

Feeler Gauge (1)

Deep Socket
- 1/2" Drive - 13/16"

Sockets - 1/2" Drive

1"	3/4"	1/2"
15/16"	11/16"	7/16"
7/8"	5/8"	3/8"
13/16"	9/16"	

Sockets - 3/8" Drive

3/4"	9/16"	3/8"
11/16"	1/2"	5/16"
5/8"	7/16"	1/4"

Adaptors •/
- 1/2" Drive to 3/8"
- 3/8" Drive to 1/2"

Nut Spinner or Breaker Bar
- 8" - 3/8" Drive
- 16" - 1/2" Drive

Sliding T Handle
- 6" - 3/8" Drive
- 10" - 1/2" Drive

INSTRUCTOR'S UNIT PLAN

Unit 14
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Engine Troubleshooting, Tune-Up and Seasonal Care**

AIM: To develop student's ability to troubleshoot, identify and repair malfunctions occurring in small gasoline engines.

To have the student develop the proper procedure for seasonal care of machinery to lengthen the servicable life of the equipment.

INSTRUCTIONAL AIDS:

Four stroke and two stroke cycle engines.

Suitable repair manuals for engines that students are working with.

Slides, 35 mm - Set No. 2 . . . 27 slides, **Check-up:** Briggs & Stratton Corporation, Milwaukee, Wisconsin 53201.

Slides, 35 mm - Set No. 7 . . . 28 slides, **Start, Stop and Store:** Briggs & Stratton Corporation, Milwaukee, Wisconsin 53201.

Film - **Automotive Service,** United World Films, Inc., 605 W. Washington Building, Chicago, Ill. (Rent or purchase, 11 minutes, 16 mm).

Film - **Automotive Trouble Shooting and Engine Tune-Up,** United World Films, Inc., 605 W Washington Building, Chicago, Ill. (Purchase, 33 minutes, 16 mm).

Film - **Engine Tests and Tune-Up,** Teaching Aids Exchange, P. O. Box 3527, Long Beach, California (Rental, 18 minutes, 16 mm).

EQUIPMENT:

16 mm projector, screen, oil (10 weight for fuel-oil mixture), steam cleaner, suitable grind stone, blade balance, special tools, hand tools and electric engine analyzer and magneto tester.

PRIMARY REFERENCES:

1) **Briggs & Stratton Repair Instructions III and Supplement,** Milwaukee: Briggs & Stratton Corporation.

2) **General Theories of Operation,** Milwaukee: Briggs & Stratton Corporation.

3) Long, Kenneth F., **Small Engines Service Manual,** 1014 Wyandotte Street, Kansas City, Mo.: Technical Publications, Inc., 1966.

4) Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., 1960.

I. INTRODUCTION and MOTIVATION

A. Preview (selected) film, discuss points of special interest, relate content to the small engine field.

B. Develop discussion leading to point that small malfunctions will be main reasons for service.

C. Develop discussion leading to point that engines are often used only one-half of the year and proper care should be exercised to assure long life for engines.

II. PRESENTATION OF INTEGRATED CONCEPTS

	RELATED CONCEPTS	
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Malfunctions. 1. Ignition system 2. Fuel system 3. Starter system 4. Compression 5. Governor	1. Identification of malfunctions. a. Ignition system 1) Spark plug 2) Points - condenser 3) Timing 4) Troubleshooting procedures b. Fuel system 1) Stoppage 2) Leakage 3) Breakage 4) Carburetor a) Overflow b) Excessively lean c) Adjustment c. Starter system 1) Inoperative 2) Will not engage 3) Will not disengage d. Compression 1) Low 2) Blow by problems e. Governor 1) Shunts 2) Will not allow R.P.M. increase 3) Will not allow R.P.M. decrease	1. Fuel contamination. a. Loss of volatility b. Moisture 1) In fuel 2) In closed area with fuel 2. Resistance and materials. a. Resistors b. Electrostatic manufacture of resistance materials
B. Troubleshooting procedures. 1. Special equipment	1. Troubleshooting procedures. a. Logical progression b. Use of special equipment during procedure	
C. Safety for type of equipment. 1. Vibration 2. Cracks or tears 3. Metal used for construction	1. Equipment check. a. For visual defects 1) Bends, tears, cracks b. Alignment and balance of parts c. Metal of construction 1) Weldability 2) Proper repair	1. Scientific method of problem solving. a. Development of hypothesis b. Use of facts to support proof.
D. Seasonal Care. 1. Sharpening a. Balance b. Safety 2. Exterior cleaning and weatherproofing a. Control cable oiling b. Painting	1. Tool sharpening. a. Proper method 1) Sharpening equipment 2) Equipment (rotary operating object) balance 3) Safety a) Eye b) Other	1. Metal deterioration. a. Natural b. Unnatural 1) Effects of chemicals on metal 2) Neutralizers c. Protective coating materials 1) Permanent

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Graph. a. Identification of sectors b. Addition and subtraction of forces within a graph c. Cylinder pressure with no combustion d. Cylinder pressure with combustion e. Develop various forms of graphs 1) Bar graph 2) Line graph 3) Pie graph	1. Owner's manual section on troubleshooting.	1. Application identification. a. Small engines b. What uses? c. Practical for that area d. Best type of engine for the specific job e. Shore resort area as compared to industrial area
1. Electrical graph. a. D.C. current build-up in circuits b. Pulsating D.C. current c. A.C. current	1. Owner's manual safety guide section for maintenance personnel and owners.	1. Earth-moon-sun relationship. a. Tides b. Seasons c. Resultant population effects
1. Review of battery principles, operation and service. a. Graph battery output b. Graph D. C. generator output c. Graph A.C. generator output	1. Owner's manual section for seasonal care.	1. Weather. a. Atmospheric conditions b. Rain patterns c. Resultant population effects

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
3. Internal preparation for storage a. Fuel system b. Cylinder	b. Exterior cleaning 1) Steam 2) Other safe methods 3) Prepartion to paint 4) Painting 5) Weatherproofing (storage) 6) Proper lubrication of all flexible control cables c. Internal storage 1) Fuel system 2) Ignition system 3) Cylinder bore 4) Valves	2) Temporary 3) Coating removal methods

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES

III. APPLICATION

A. Students should be required to determine source of malfunctions using diagnostic equipment.

B. Students should display knowledge of seasonal care by cleaning, sharpening and preparing lawn mower, edger (or other suitable device) for storage.

C. Students should be required to remove from storage and put into operational service a unit that has been properly stored.

IV. EVANUATION CRITERIA GUIDELINE

A. Identify the basic troubleshooting procedures for small gas engines.

B. Why is seasonal care necessary in small engines?

C. Where do most of the necessary service on a small engine originate?

V. SUMMARY

Review identification of engine malfunctions and the recommended troubleshooting procedures used to analyze the malfunctions. Be sure to point out safety procedures and precautions.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts

45 minutes . . . Math

45 minutes . . . Communications

45 minutes . . . Social studies

45 minutes . . . Science

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Crouse, William H., **Automotive Electrical Equipment**, New York: McGraw-Hill Book Company, Inc., 1959.

2) Crouse, William H., **Automotive Mechanics**, New York: McGraw-Hill Book Company, Inc., 1965.

3) Pipe, Ted, **Care and Repair of Your Small Gasoline Engines**, New Augusta, Ind.: Editors and Engineers, Ltd.

4) Rosskopf, Myron F., **Modern Mathematics for Jr. High School**, Morristown, N. J.: Silver Burdett Company, 1961.

INSTRUCTOR'S UNIT PLAN

Unit 15
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

SUBJECT: SMALL POWER SOURCES

DIVISION: **Additional Internal Combustion Power Sources**

AIM: To develop a background knowledge of internal combustion power sources other than the small lawn mower type engines.

INSTRUCTIONAL AIDS:

Transparencies - **Rotary Engine,** Philadelphia, Pennsylvania: DCA Educational Products, Inc., 4865 Stanton Avenue.

Film - **ABC of the Diesel Engine,** Detroit: General Motors Corporation, Educational Relations Department, Department of Public Relations, Box 177, North End Station (Free, 20 minutes, 16 mm).

Film - **Steps to Jets,** #1831, Pittsburgh, Pennsylvania: Modern Talking Pictures (Purchase, 18 minutes, 16 mm).

Film - **The Gas Turbine,** Flushing, New York: Shell Oil Company, Film Library, 149-07 Northern Blvd. (Rental, 15 minutes, 16 mm).

Small operational gas turbine, charts, illustrations, models and pictures of engines.

EQUIPMENT:

16 mm projector, overhead projector, screen, Wankel and diesel engines attached to Go-Power testing units.

PRIMARY REFERENCES:

1) **A Power Primer** and **Diesel: The Modern Power,** Detroit: General Motors Corporation (Booklets).

2) **Curtis-Wright RCI-6.6 Rotating Combustion Engine Operating Manual,** Woodbridge, New Jersey: Wright Aeronautical Division, Curtis-Wright Corp.

3) Duffy, Joseph W., **Power: Prime Mover of Technology,** Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

4) Kates, Edgar, **Diesel and High-Compression Engine Fundamentals,** Chicago: American Technical Society, 1966.

5) Tobeldt, William K. and Purvis, Jud, **Motor Service's Automotive Encyclopedia,** Homewood, Ill.: The Goodheart-Willcox Company, Inc., 1965.

I. INTRODUCTION and MOTIVATION

A. Introduce the unit through the use of one of the films recommended, illustrating a variety of internal combustion power sources.

B. Identify employment opportunities as they relate to specific power plants, i. e., diesel engine mechanics, aviation mechanics, etc.

C. Discuss the similarities and differences between a variety of internal combustion engine power plants.

II. PRESENTATION OF INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. History of diesel engine. 1. Invention 2. Efficiency 3. Similarity	1. Inventor. a. Dr. Diesel b. Where developed 2. More work from fuel a. One of most efficient engines 3. Small engine and diesel similarity. a. Fuel system b. No ignition system 1) Starting only 2) Cold weather c. Lubrication	1. Heat units. a. British Thermal Units 1) History 2) How derived 3) Application b. Fuel combustion with no ignition 1) High compression producing high temperature 2) Fuel injection as a determiner of power c. Use of low grade fuel d. Comparison to gas engine
B. History of rotary combustion (Wankel Engine). 1. Internal design 2. Advantages-disadvantages 3. Principle of operation	1. Inventor. a. Wankel, Felix, German, 1956. 2. Internal. a. Combustion chamber design b. Crankshaft design c. Ignition event d. Power impulses 3. Advantages. a. Rotary motion not reciprocating b. Power impulses c. Problems 4. One cycle of rotor.	1. Rotary and reciprocating motion. a. Difference b. Vibration resultant c. Inertia
C. Gas turbine history. 1. Internal design 2. Advantages (problems) 3. Principle of operation	1. Inventor. a. First patent . . . John Barber, 1791 b. England 2. Internal. a. Compressor b. Combustion chamber c. Turbine d. Exhaust 3. One cycle of operation.	1. Gas laws. a. Gas flow 1) In compressor 2) When heated 3) Action when flow across turbine 4) Power transfer

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Horsepower formulas. a. Compression ratio 1) Small gas engine 2) Diesel 3) Wankel 4) Gas turbine b. Methods of application	1. Descriptive literature describing each units operation other than small engine.	1. Social-economic impact of the development of the diesel engine. a. Past b. Present c. Future d. On a community
1. Best selection. a. Specific fuel consumption b. Requirements vs. available c. Practical application to specific problems 2. Graph fuel consumption and power output. 3. Compare efficiency of diesel to gas engine.	1. Literature describing how to select unit best suited for an application.	1. Social-economic impact of the development of the Wankel engine. a. Past b. Present c. Future d. On a region
1. Engine fuel efficiency. a. BTU content of fuel b. Horsepower output of engine c. Application to specific problems	1. Safety manual for the owner of each unit a. Operation b. Service . . . repair 2. Fundamental English grammar work. Parts of speech or patterns (depending on instructor orientation). 3. Required research for development of the above literature and manual. 4. Completion of owner's manual. a. Operational section b. Repair-troubleshooting section c. Storage section 5. Graphic arts area for bookbinding.	1. Social-economic impact of the development of the gas turbine engine. a. Past b. Present c. Future d. On a nation 2. Problems presented by described units. a. Atmospheric b. Geographical c. Population shifts 3. Time-space relationship change in society due to units development.

III. APPLICATION

Students should demonstrate knowledge through identification of components, schematics and vocabulary usage as well as through light checking and tune-up of these other power sources.

IV. EVALUATION CRITERIA GUIDELINE

A. Explain why the diesel engine is more efficient than the gasoline engine.

B. Describe how turbine and rotary engines work.

C. Why aren't diesel engines used more frequently in automobiles?

V. SUMMARY

Other power sources that seem to be having quite an impact on engine industry are the Wankel engine, gas turbine and the most developed of these, the diesel engine.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communications.

45 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Epstein, Samuel and Beryl, **All About Engines and Power,** New York: Random House, Inc., 1962.

2) **Go-Power Engine Analysis Systems,** 155 Montgomery Street, San Francisco: Go-Power Corporation, 1966.

3) Morgan, Alfred P., **Boys' Book of Engines, Motors and Turbines,** New York: Charles Schribner's Sons, 1953.

4) Stephenson, George, **Power Mechanics,** Albany, New York: Delmar Publishers, Inc., 1963.

INSTRUCTOR'S UNIT PLAN

Unit 16
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Basic Principles of Electric Motors**

AIM: To have the student develop a knowledge of the principles of operation of electrical motors and how to service their component parts.

INSTRUCTIONAL AIDS:

Charts, illustrations and models of electrical motors, their fields and armatures.

Film - **How to Make a Motor Go,** Milwaukee: Allis-Chalmers Manufacturing Company, Industries Group (16 mm).

Film - **AB Circuit Breakers,** Pittsburgh, Pennsylvania: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 10 minutes, 16 mm).

Slide Film - **Electric Motors, Detroit:** Jam Handy, 281 E. Grand Blvd. (Purchase, 66 frames, 35 mm).

Slide Film - **Motors,** Berkeley, California: Land Filmslide Service, 944 Riegal Road (Purchase, 35 mm).

Phamplet - **Squirrel Cage Induction Motors, CSS No. 3,** Pittsburgh, Pennsylvania: Westinghouse Corporation, School Service, P. O. Box 1017 (Free, 2 units).

EQUIPMENT:

16 mm projector, 35 mm projector, screen, battery and wire, voltage and current measuring equipment, continuity tester, magnets, miscellaneous pieces of bar stock and miscellaneous small motors for teardown.

PRIMARY REFERENCES:

1) Crow, Leonard R., **Learning Electricity Fundamentals,** Indianapolis: The Howard W. Sams Company, Inc., 1957.

2) Mileaf, Harry, Editor-In-Chief, **Electricity One-Seven,** New York: Hayden Book Company, Inc., 1966.

3) Sams, Howard W., **Basic Electricity and An Introduction to Electronics,** Indianapolis: The Howard W. Sams Company, Inc., 1967.

4) Turner, Rufus P., **Basic Electricity,** New York: Holt, Rinehart and Winston, Inc., 1967.

I. INTRODUCTION and MOTIVATION

A. To repair, one must understand operation.

B. Once the operation is understood, the need for safety is understandable.

C. Electric hand tools and other equipment are on the increase, so this field requires the aid of many people.

D. Film (selected). Preview the major concepts to be developed.

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Magnetic fields. 1. Attraction 2. Repulsion 3. Warp	1. Unlike magnetic fields. a. Attract b. Rotating permanent pole field action 2. Like magnetic fields. a. Repulse b. Rotating permanent pole field action 3. Lines of force will warp. a. Field interaction b. Adjustment for warp	1. Insulator. a. Atomic structure 1) Compare with conductor 2) In conjunction with conductor b. In nature c. Man-made
B. Strength of field. 1. Single wire 2. Multi-winding 3. Armature - field 4. Current	1. Single wire electron flow. a. Direction 1) Laws 2) Resultant 2. Multi-wire. a. Increase in field strength b. Resultant 3. Armature - field a. Interaction of magnetic fields b. Resultant 4. Current. a. Resultant of change of single field b. Resultant of change of dual field	1. Heat characteristics of insulators. a. Natural b. Synthetic c. Breakdown
C. Current flow. 1. Heat 2. Insulation 3. Control 4. Method of completing path a. Slip ring b. Brushes	1. Electron flow. a. Method of flow b. Heat resultant c. Effect of heat 2. Insulation. a. Types b. Inspection 3. Control. a. Switches b. Variable devices 4. Current path. a. Slip rings 1) Brushes 2) Surface b. Commutator 1) Segments 2) Separators 3) Brushes	1. Resultant of insulator breakdown. a. Transmission lines b. Home (to wall plug) c. Home (after wall plug) d. Internal to equipment

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Electrical motor torque. a. Formula b. Practical problems	1. Research paper. a. Comparsion of internal combustion engine and electrical power motor b. Advantages and disadvantages of each c. Significant current uses of each in American industry.	1. Social impact of electricity. a. Industries affected b. Labor changes c. Compare have-have not areas d. Why do some areas not develop electricity?
1. Electrical motor design. a. Job appliction Torque requirement 2) Power input 3) Losses b. Winding and/or gearing design c. Relation of number of turns in armature to field strength.	1. Paragraph development: a. Topic sentence b. Development c. Clincher sentences d. Transitionals	1. The earth's magnetic fields. a. Location of b. Uses c. Problems 1) True North 2) Magnetic North 3) Variation
1. Ratios. a. Pulley and belt b. Direct gear combination c. Planetary systems 1) Single 2) Multiple	1. Section for electrical manual a. Safety b. Operation of circuit breakers and fuses c. (Any motor type) Descriptive literature on operation of the motor	1. Problems of electrical companies. a. Production 1) Requirements 2) Storage b. Distribution 1) Property 2) Equipment c. Government controls d. Public relations with communities

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
D. Motor types. 1. A.C. a. Squirrel cage b. Capacitor c. Split-phase d. Synchronous e. Induction f. Others 2. D.C. motors a. Shunt b. Series c. Compound 3. Universal motor	1. Motor types. a. A.C. 1) Operation of: a) Squirrel cage b) Capacitor c) Split-phase d) Synchronous e) Induction f) Others b. D.C. 1) Operation of: a) Shunt b) Series c) Compound 2) Practical size development of each c. Universal 1) Operation of 2) Practical size development of	1. Insulator choice. a. Basis b. Application methods c. Control processes
E. Practical application. 1. Fractional horsepower 2. Above one-horsepower 3. Motor type	1. Application: a. Fractional 1) Home 2) Industry b. Above onehorsepower 1) Home 2) Industry c. Motor type based on use	1. Research methods. a. Application requirements b. Research procedures
F. Circuit symbols.		

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Ohm's Law. a. Voltage - current - resistance b. Control 1) Single speed 2) Multispeed 3) Practical application c. Power consumption 1) Formula 2) Practical application d. Metered circuit experiments to demonstrate Ohm's Law under variable resistance	1. Letters to manufacturers for literature covering their equipment. a. Hand tools b. Other tools c. Appliances	1. A typical American house. a. Uses of electricity b. Motorized equipment c. Compare the individual home job relief-labor with the particular electrical motor 2. Compare standard of living of families who have electricity with those who do not.

III. APPLICATION

A. Student should wind armature and fields for small electric motor.

B. Student should reproduce motors and circuits utilizing the proper symbols.

C. Student should dismantle small motors and identify the internal components.

IV. EVALUATION CRITERIA GUIDELINE

A. Based upon winding of small motor armature and field.

B. Ability to reproduce motor and circuit symbols.

V. SUMMARY

Summarize with emphasis on these points:

A. Magnetic fields.

B. Current flow and effect upon magnetic fields.

C. Current flow resultants.

D. Motor types.

E. Circuit symbols.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communications.

45 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Dunsheath, Percy, **Electricity: How it Works.** New York: Thomas Y. Crowell Company, 1960.

2) Graham, Kennard C., **Fundamentals of Electricity.** Chicago: American Technical Society, 1967.

3) Wright, Forrest B., **Electricity in the Home and on the Farm.** New York: John Wiley & Sons, Inc., 1950.

INSTRUCTOR'S UNIT PLAN

Unit 17
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Equipment for Testing Electrical Appliances**

AIM: To have the student develop a working knowledge of electrical testing devices.

INSTRUCTIONAL AIDS:

Charts, illustrations and models of multimeters, vacuum tube voltmeter, continuity testing lights and meters.

Actual multimeter, vacuum tube voltmeter, continuity testing lights and meters.

Small motors, resistors, capacitors, fuses, circuit breakers, wiring and plugs.

Growler.

EQUIPMENT:

See instructional aids.

PRIMARY REFERENCES:

1) Hertzberg, Robert, **Repairing Small Electrical Appliances,** New York: Arco Publishing Company, Inc., 219 Park Avenue South, 1968.

2) McPartland, Joseph F. and Novak, William J., **Electrical Equipment Manual,** New York: McGraw-Hill Book Company, Inc., 1965.

3) Mileaf, Harry, Editor-In-Chief, **Electricity One-Seven,** New York: Hayden Book Company, Inc., 1966.

I. INTRODUCTION and MOTIVATION

A. Testing equipment saves time by isolating problem.

B. Knowledge of test equipment will allow you to identify the problem quickly and accurately.

C. Safety in the use of the testing equipment is also necessary.

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Continuity light. 1. Complete circuit 2. Light indication	1. Safety in meter testing. 2. Circuitry. a. Complete circuit b. Open circuit c. Grounded circuit d. Shorted circuit 3. Indications. a. Complete circuit b. Open circuit c. Grounded circuit d. Shorted circuit e. Resistance 4. Construction. a. For specific system voltage b. For more than a single circuit voltage	1. Light. a. How formed 1) Sun 2) Moon 3) Artificial b. Types 1) Arc 2) Neon 3) Fluorescent 4) Incandescent c. Gases utilized 1) Where obtained 2) How utilized d. How resistance and current flow are related to wattage rating of lamps e. Atomic origins of light
B. Vacuum tube voltmeter.	1. Safety 2. Construction. 3. Use. a. Precision readings b. Use in tests	1. Metals used. a. Selection b. Why utilized
C. Multimeter.	1. Safety. 2. Most portable for more than one test. a. Indications on meter b. Selectivity c. Probe selection 3. Power. a. Self-contained b. Renewable c. Student application 4. Operation. a. How meter is circuited for indications 1) Resistance 2) Voltage 3) Continuity 4) Schematics of internal (use of circuit symbols. b. Interpretation of indications 1) Needle deflections 2) No needle deflection	1. Comparision to light production. a. Vacuum tube b. Resistor c. Capacitor

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Transformers. a. Ratios b. Step-up and step-down 1) Formulas 2) Design c. Voltage drop 1) Formulas 2) How restored	1. Manual. a. Sections on proper use of and care of: 1) Continuity light 2) Vacuum tube voltmeter 3) Multimeter 4) Growler b. Safety instructions for use of each	1. Map . . . world-wide a. Power sources (water) that appear they could be developed 1) Why have they not 2) Could the power be used if developed
1. Circuits. a. Vector addition b. Vector subtraction c. Graph 1) Vector resultant 2) Vectors to wave-form. d. Resistive e. Inductive f. Capacitive	1. Basic writing skills. a. Develop variety through vocabulary enrichment b. Sentence structure variety	1. To become industralized, what do the areas need? a. Skills b. Construction c. Financial 1) Sources 2) Government impact d. Transportation e. Health f. Education g. Natural resources
1. Supply unknown quanities. a. Use of instruments 1) Determine resistance, use Ohm's law 2) Determine voltage, use Ohm's law 3) Determine current, use Ohm's law b. Accomplish power requirements 1) Unit demands in amperes-wattage requirements 2) Ampere-wattage voltage requirements	1. Section in manual on safety concerning working with special bulbs and lighting tubes.	1. Appliances available. a. Per unit area U.S.A. b. Per unit area in the rest of the world c. Reasons for distribution

II. PRESENTATION OF INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
D. Growler.	1. Safety. 2. Operation. a. Light b. Meter c. Field 3. Indication. a. Interpretation of indications b. When used 1) Before rewind 2) After rewind	1. Human body. a. Conductivity b. Resistance c. Changes due to 1) Weather 2) Human elements 2. Interaction of magnetic fields a. In space b. In a medium c. Between mediums 3. Effect of vacuum. a. Magnetic fields b. Electrical operation c. Metals

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
	1. Construct articles for the layman explaining: a. Transformers b. A circuit c. A continuity light d. The multimeter e. The growler	1. Appliance availability impact upon the social structure.

III. APPLICATION

A. Students will be required to demonstrate knowledge by utilizing test equipment to obtain accurate readings and indications.

B. Circuits will be constructed to allow students to observe readings on the test equipment.

IV. EVALUATION CRITERIA GUIDELINE

A. Practical application examinations will be constructed.

B. Students will demonstrate their knowledge of the test equipment by constructing schematics of the test equipment.

C. Students will be required to construct simple test equipment items.

V. SUMMARY

Summarize the general characteristics and operation of:

A. Circuits.

B. Continuity light.

C. Vacuum tube voltmeter.

D. Multimeter.

E. Growler.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts.

45 minutes . . . Science.

45 minutes . . . Math.

45 minutes . . . Communications.

45 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Crouse, William H., **Electrical Appliance Servicing**, New York: McGraw-Hill Book Company, Inc., Trade Department, 330 West 42nd Street, 1950.

2) Green, Philip T., **Electrical Testing and Troubleshooting**, New York: The Industrial Press, Inc., 1956.

3) Rider, John F. and Prensky, Sol D., **How to Use Meters**, New York: John F. Rider Publisher, Inc., 1960.

INSTRUCTOR'S UNIT PLAN

Unit 18
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Portable Electrical Tools**

AIM: To have the student become aware of the portable electric tools, their differences and uses and to be able to service them.

INSTRUCTIONAL AIDS:

Charts, illustrations and models of portable drill motors, sanders, impact wrench power units and others.

Operable portable drill motors, sanders, impact wrench power units, power tool extensions (snakes and others).

Hand and special tools necessary to dismantle the above equipment and motors.

EQUIPMENT:

See instructional aids.

PRIMARY REFERENCES:

1) Carville, T. E. M., **Fractional Horsepower Motor Maintenance,** Scranton, Pennsylvania: The Haddon Craftsmen, Inc., 1949.

2) McPartland, Joseph F. and Novak, William J., Associate Editor, **Electrical Equipment Manual,** New York: McGraw-Hill Book Company, Inc., 1965.

3) Rosenberg, Robert, **Electric Motor Repair,** Brooklyn, New York: Holt, Rinehart and Winston, Inc., Technical Division, 1960.

4) Schweitzer, Gerald, **Basics of Fractional Horsepower Motors and Repair,** New York: John F. Rider Publisher, Inc., 1960.

(Note: Each instructor should contact manufacturers of equipment and be added to their mailing lists. This will insure that the instructor has the most up-to-date references in his possession.)

I. INTRODUCTION and MOTIVATION

A. Portable electric tools reduce work for the individual.

B. Range from vacuum cleaner to tree sawing.

C. Each unit has the electric motor in common.

D. Differences in tools are such items as gears (or drive units) and cases.

II. PRESENTATION OF INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Portable tools. 1. Basic utilization a. Drill motors b. Sanders c. Impact wrenches d. Saws e. Others 2. Basic device a. Electric motor b. Drive connection	1. Reason designed. a. Drill Motor 1) Drill 2) Basis for other attachments b. Sanders 1) Belt 2) Rotary 3) Reciprocating c. Impact wrenches 1) Rotary 2) Reciprocating d. Saws 1) Reciprocating 2) Rotary e. Other applications 2. Basic device. a. Electric motor b. Gear trains 1) Gear type Gear systems designs	1. Plastics. a. Materials 1) Source 2) Types b. Uses 1) Insulation 2) Framing 3) Packaging
B. Individual construction.	1. Individual construction. a. Types 1) Drill motors a) A.C., D.C. or Universal b) Differences 2) Sanders a) A.C., D.C. or Universal b) Differences 3) Impact Wrenches a) A.C., D.C. or Universal b) Differences 4) Saws a) A.C., D.C. or Universal 5) Other equipment a) A.C., D.C. or Universal motor b) Differences	1. Forming plastics. a. Methods b. Comparison 1) Plastics 2) Metals 3) Resultant a) Safety of b) Quality of
C. Disassembly of equipment.	1. Disassembly procedures. a. Drill motors b. Sanders c. Impact wrenches d. Saws e. Others	1. Replacement of metal gearing. a. Comparative strength. b. Wear comparsion.

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. R.P.M. reduction. a. Input-output b. Resultant power gain-loss	1. Manual sections on: a. Drill motors b. Sanders c. Impact wrenches d. Saws e. Others	1. Earth-water cycle. a. Evaporation b. Clouds c. Topography and its effect d. Return to the sea
1. Reduction-gain. a. Straight gearing b. Planetary system 1) Single speed 2) Multi-speed	1. Safety section for operation of each of the above.	1. Social customs formulated by the water cycle. a. Wet regions b. Dry regions c. River areas d. Sea coast e. Mountian regions f. Inland regions
1. Foot (and/or inch) per minute travel. a. Drills b. Sanders c. Saws	1. Basic writing skills. a. Development of the compound sentence b. Use of subordinating and co-ordinating conjunctions	1. Ability of above cultures to become industrialized. 2. Desirability for above regions to become industrialized. 3. Possible effect on agricultural productivity of above regions if they become industrialized.

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
D. Assembly of equipment.	1. Assembly procedures. a. Drill motors b. Sanders c. Impact wrenches d. Saws e. Others	1. Lubricants. a. Suitability 1) Heat 2) Abuse a) Metal b) Plastics
E. Equipment operation.	1. Proper operation. a. Drill motors b. Sanders c. Impact wrenches d. Saws e. Others 2. Proper operation as a test.	1. Lubricants. a. Liquids 1) Advantages 2) Disadvantages b. Semi-liquids 1) Advantages 2) Disadvantages c. Problems 1) Distribution 2) Sealing
F. General services required.	1. Oiling. 2. Cleaning. 3. Repair of cords, plugs and case. 4. Replacement of parts (brushes, switch, armature, etc.).	1. Inertia. a. Remain in motion b. Remain at rest c. Change of direction resistance. 2. Metal identification. a. Systems b. Need for

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Circle segmentation. a. By parts b. By degrees c. Application 1) Degree travel to segmentation 2) Wave-form application to work potentional	1. Section for manual. a. Describe need for computation of foot (and/or inch) per minute travel b. Arrange formulas c. Sample problems	

III. APPLICATION

A. Students will be required to disassemble and reassemble tool drives that are different in their application.

B. Students will be required to produce schematics for each piece of equipment dismantled.

C. Students will be required to operate each tool dismantled in the job it was designed to accomplish.

D. Students should be able to service or repair electric tools.

IV. EVALUATION CRITERIA GUIDELINE

A. Student shall be evaluated upon his ability to disassemble, identify, service or repair and reassemble the electrical tools.

B. Evaluate upon student ability to draw schematics of equipment utilizing the proper symbols.

C. Proper use of the equipment as it was designed to be operated. Evaluation to assure the student can test his work.

V. SUMMARY

Stress the following:

A. Portable tool identification.

B. Power unit drive.

C. Individual unit construction.

D. Disassembly - assembly of units.

E. Proper operation of equipment for testing of repairs.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts

40 minutes . . . Science

40 minutes . . . Math

40 minutes . . . Communications

40 minutes . . . Social studies

20 minutes . . . Summary and evaluation

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Anderson, Edwin P., **Electric Motor Guide**, 49 West 23rd Street, New York: Theodore Audel & Company, 1963.

2) Carville, T. E. M., **Fractional Horsepower Motor Maintenance**, Scranton, Pennsylvania: The Haddon Craftsmen, Inc., 1949.

3) Wright, Forrest B., **Electricity in the Home and on the Farm**, New York: John Wiley & Sons, Inc., 1950.

INSTRUCTOR'S UNIT PLAN

Unit 19
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Appliance Servicing**

AIM: To develop an understanding of the operation and service of common household appliances.

INSTRUCTIONAL AIDS:

Portable electric tools.

Washing machines, automatic and wringer-type.

Dryers, coffee makers, toasters, vacuum cleaners and other appliances.

Liquid and semi-liquid lubricants.

Necessary small hand tools.

Film - **Home Electrical Appliances,** No. 721, New York: American Museum of Natural History Film Library, Central Park West, 79th Street (Rental, 1 reel, 16 mm).

Film - **How to Take Step Seven,** Milwaukee, Wisconsin: Allis-Chalmers Manufacturing Company, Industries Group (Free, 20 minutes, 16 mm).

Film - **Learning About Electric Current, No. 1090,** New York: American Museum of Natural History Film Library, Central Park West, 79th Street (Rental, 1 reel, 16 mm).

EQUIPMENT:

16 mm projector and screen.

PRIMARY REFERENCES:

1) Anderson, Edwin P. **Home Appliance Service Guide,** New York: Theodore Audel & Company, 1954.
2) Crouse, William H., **Electrical Appliance Servicing,** New York: McGraw-Hill Book Company, Inc., Trade Department, 330 West 42nd Street, 1950.
3) **Technical Data,** Louisville, Kentucky: General Electric, Major Appliance Division, Appliance Park (Note: Information available on specific models).

I. INTRODUCTION and MOTIVATION

A. Preview (selected) film. Point out specific concepts to be developed.

B. Preventative maintenance saves equipment breakdown and assures maximum life for the equipment.

II. PRESENTATION OF INTEGRATED CONCEPTS

RELATED CONCEPTS

INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Data. 1. Location 2. Application	1. Location. a. Model identification b. Data determination 2. Application. a. Proper selection of such items as lubricants b. Proper application 1) No overfilling 2) Ability to work clean	1. Air. a. Constitution 1) Usable a) Human b) Other b. Change 1) Man additives 2) Natural action to balance 3) Present problems 4) Projected problems
B. Preventative maintenance. 1. Disassembly 2. Servicing 3. Serviceability 4. Assembly	1. Disassembly. a. Utilizing proper procedures described in manual 1) No force unless specified 2) Selection of tools and disassembly procedure 2. Servicing. a. Securing data b. Proper servicing procedures as directed in service manuals c. Importance of cleanliness 3. Serviceability. a. Plugs b. Cords c. Internal wiring d. Gears and belts e. Seals 1) Lubricant 2) Vapor 4. Assembly. a. Proper procedures b. No force, unless specified	1. Water. a. Constitution 1) Usable a) Human b) Other b. Change 1) Man additives 2) Natural action to balance 3) Present problems 4) Projected problems

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Formula application. a. Torque 1) Prony brake 2) Dynamometer b. Using equipment 1) Ratios from available gearing 2) Motor R.P.M. vs. cutting tool speed 3) Determining allowable speed of cutter (chart interpretation).	1. Owner's manual section. a. Advising preventive maintenance b. Daily care of the appliance (external) c. Proper utilization of equipment for its design	1. Power tool advantages. a. Construct module of home with non-powered tools 1) No electrical outlets 2) Sewer and gas fixtures included, including gas for lighting b. Construct module of home with powered tools 1) Electrical circuits to be installed carefully a) Proper connection to power lines b) Proper house service box c) Fusing of each circuit d) Wire selection for each circuit 2) Sewer and gas fixtures
1. Friction. a. Horsepower output vs. computed horsepower input. b. How to determine (formula) c. Sources of friction	1. Basic writing skills. 2. Supplementary reading in . . . fictonal works with automotive focus, i.e., *Hot Rod* by Henry G. Felsen.	1. House planning. a. What to include b. Design for value c. Module planning d. What does the typical American family require?

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
C. Operational testing.	1. Unload operational test. 2. Operational load test. a. Specifications location b. Determine if serviced item meets specifications	1. Electricity production. a. Problems 1) Air pollution 2) Water pollution b. Methods of correction 1) Air pollution 2) Water pollution c. Electricity problems vs. internal combustion engine problems 1) Compare emissions Research present and proposed processes for correction of pollution

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Meters. a. Ohm's Law 1) Full current 2) Fractional current determination b. Interpretation of readings for application	1. Safety for equipment a. Grounding b. Cautions 1) Frayed cords 2) Deteriorated plugs 3) Liquids a) Water b) Explosive	1. Waste disposal. a. Combustibles b. Non-combustibles c. Sewage 2. Effect upon ecology. a. Reduction b. Pollution due to improper treatment

III. APPLICATION

A. Students will service various units such as washing machines, dryers, toasters and such other items that are available.
B. Students will be required to determine the condition of and advisability of continued use for belts, cords and plugs as well as internal wiring.
C. Students will demonstrate proper procedure in locating servicing data.

IV. EVALUATION CRITERIA GUIDELINE

A. Evaluate on location of servicing data.
B. Evaluate on application of data to the machinery.
   1. Proper data.
   2. Proper application.
C. Manual dexterity in use of equipment.

V. SUMMARY

Review:

A. Data location and interpretation.
B. Preventative maintenance.
C. Operational testing.

VI. SUGGESTED TIME and SEQUENCE LISTING

180 minutes . . . Instructional topics and technical concepts
40 minutes . . . Science
40 minutes . . . Math
40 minutes . . . Communications
40 minutes . . . Social studies
20 minutes . . . Summary and evaluation

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Hertzberg, Robert, **Repairing Small Electrical Appliances**, 219 Park Avenue South, New York 10003: Arco Publishing Company, Inc., 1968.

2) Manly, H. P., **Electric Appliance Repair and Troubleshooting**, Chicago: Frederick J. Drake & Company, 1958.

INSTRUCTOR'S UNIT PLAN

Unit 20
Lesson 1
Time . . . . . 6 hours

CLUSTER: TRANSPORTATION

DIVISION: SMALL POWER SOURCES

SUBJECT: **Troubleshooting and Maintenance of Electric Tools and Equipment**

AIM: To have the student develop the ability to:

A. Read wiring diagrams.

B. Identify, isolate and repair problems connected with portable electric tools.

C. Identify, isolate and repair problems connected with electrical household appliances.

INSTRUCTIONAL AIDS:

Charts, illustrations and models of equipment.

Equipment with operating problems. (Note: Check for possible injury sources prior to allowing students to be exposed to inoperable equipment).

Electrical diagrams of equipment to be used.

EQUIPMENT:

Meters, special testing devices as required, hand and special tools as required, plugs, cords, wires for repair of defective parts and stock of parts that pertain to the equipment to allow repairs to be effected.

PRIMARY REFERENCES:

1) Campbell, Edward A., **How to Repair Home Appliances.** New York: Arco Publishing Company, Inc., 1957.

2) Green, Philip T., **Electrical Testing and Troubleshooting.** New York: The Industrial Press, Inc., 1956.

3) Manly, H. P., **Electrical Appliance Repair and Troubleshooting.** Chicago: Frederick J. Drake & Company, 1958.

4) Rosenberg, Robert, **Electric Motor Repair.** Brooklyn, New York: Holt, Rinehart and Winston, Inc., Technical Division, 1960.

I. INTRODUCTION and MOTIVATION

A. This lesson will give the student the chance to apply all his past training.

B. To do so effectively, he needs to be able to read the wiring diagrams quickly and accurately. Students should learn to do so in this lesson.

C. Work safely, accurately and quickly to learn maximum.

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
A. Circuit diagrams. 1. A.C. circuits 2. D.C. circuits	1. Complete circuit. a. Circuit polarity b. Ground circuit for safety c. Devices affecting completed circuit 2. Complete circuit. a. Circuit polarity b. Ground circuit for safety c. Devices affecting completed circuit	1. Metals. a. Coefficient of expansion 1) Pure metals 2) Mixtures of impurities (metals or other) to change characteristics b. Metals in opposition when heated c. As a control device 1) Thermoswitch 2) Fuse
B. Troubleshooting procedures.	1. A.C. circuit. 2. D.C. circuit. 3. Through devices that control circuit. a. Fuse b. Automatic cutoff c. Timers d. Thermo-conductive e. Brushes f. Windings	1. Thermal control devices. a. Bi-metallic 1) Students will construct switch 2) Students will adjust switch for different temperature openngs b. Fuse material 1) Students will make a fuse 2) Adjustment of material to allow for different current flows
C. Isolation.	1. Correct reading. a. Reading is not a complete by-pass circuit b. Bypass for test circuit	1. Wiring. a. Students will observe resultant of current overload in a wire b. Students will adjust 1) Selection of wire to carry overload c. Students will determine proper safe load for damaged wire.
D. Repair.	1. Best method. a. Repair b. Replace 2. In-shop repair. 3. Out-of-shop repair	1. Students will construct resistance device for starting fires. a. Determine resistance needed in wiring to create heat. b. Construct circuit to develop required power
E. Testing.	1. Testing. a. Determine specifications b. Testing procedures c. Determination if effective repair has been accomplished	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
1. Review. a. Ohm's Law b. Practical applications c. Power problems	1. Complete owner's manual.	1. Research and list employment opportunities in your local area.
1. Review graphs. a. Vectors 1) Addition 2) Subtraction b. Quadrants 1) Addition 2) Subtraction c. Waveforms 1) Power a) Lead-lag current b) Lead-lag voltage	1. Research paper on steps from the drafting of the manual in the classroom to the finshed product from the printer.	1. List skills needed to fill each position.
1. Repair cost. a. Parts b. Labor c. Shop d. Total to charge	1. Work on turning technical paragraphs into expository paragraphs suitable for inclusion into fictional format.	1. List positions for which you would qualify.
	1. Develop an advertising program to use in local area for an appliance repair shop. a. Direct letters b. Newspaper c. Raido spot d. Television spot	1. Choose position you would desire from those for which you qualify.
	1. Prepare one page of a parts catalogue for any appliance.	1. Outline skills needed for that position. a. Skills needed b. Skills you possess c. Skills you do not possess

II. PRESENTATION OF INTEGRATED CONCEPTS

		RELATED CONCEPTS
INSTRUCTIONAL TOPICS	TECHNICAL CONCEPTS	SCIENCE
F. Return to source.	1. Outgoing identification. a. To shipping department b. To individual	

TO BE DEVELOPED

MATH	COMMUNICATIONS	SOCIAL STUDIES
	1. Complete job applications.	1. How skills obtained. a. Education offered by public school system b. On-the-job c. Vocational school 2. Your future. a. How do you intend to become qualified? b. Outline a program to meet your specific requirements

III. APPLICATION

A. Students will troubleshoot and repair inoperable equipment.

B. Students will display proper repair technique or be required to do the job over.

IV. EVALUATION CRITERIA GUIDELINE

A. Students should be evaluated throughout the lesson.

B. Individual evaluation should be accomplished through the use of a standardized problem on a particular appliance. The use of "bugged" appliances should be used for performance testing.

V. SUMMARY

A. Circuit diagram reading as applied to a specific appliance and in general.

B. Troubleshooting procedures.

C. After isolation, choice of methods of repair.

D. Repair.

E. Testing.

F. Disposal.

VI. SUGGESTED TIME and SEQUENCE LISTING

200 minutes . . . Instructional topics and technical concepts.

40 minutes . . . Science.

40 minutes . . . Math.

40 minutes . . . Communications.

40 minutes . . . Social studies.

VII. SUPPLEMENTAL REFERENCES and RESOURCE MATERIAL

1) Anderson, Edwin P., **Home Appliance Service Guide,** 49 W. 23rd Street, New York: Theodore Audel & Company, Publishers, 1954.

2) Brockwell, P. T., **Major Appliance Servicing,** New York: McGraw-Hill Book Company, Inc., 1958.

3) Crouse, William H., **Electrical Appliance Servicing,** 330 West 42nd Street, New York: McGraw-Hill Book Company, Inc., Trade Department.

4) **Technical Data,** Louisville, Kentucky: General Electric, Major Appliance Division, Appliance Park.

(Note: Instructor should contact manufacturers and be placed on their mailing list to assure he remains up to date.)

BIBLIOGRAPHY

Adler, Irving, **The Wonders of Physics,** New York: Golden Press, Publishers, 1966.

Anderson, Edwin P., **Electric Motor Guide,** 49 West 23rd Street, New York: Theodore Audel & Company, 1963.

Anderson, Edwin P., **Home Appliance Service Guide,** 49 West 23rd Street, New York: Theodore Audel & Company, 1954.

Annett, F. A. and Roe, A. C., **Connecting and Testing Direct-Current Machines,** New York: McGraw-Hill Book Company, Inc., 1955.

Ayers, Lewis, **Small Gasoline Engines Student Handbook,** Vol. 7, No. 1, University Park, Pennsylvania: Pennsylvania State University, College of Agriculture, Department of Agriculture Education, 1966.

Barnard, J. Darrell and Others, **Book 6, Macmillan Science Life Series,** New York: The Macmillan Publishing Company, Publishers, 1959.

Barr, Donald, **Atomic Energy,** Columbus, Ohio: Charles E. Merrell Books, Inc., 1961.

Bergaust, Erik, **Rocket Power,** Eau Claire, Wisc.: E. M. Hale & Company, 1962.

Blackwood, Paul E., **Push and Pull: The Story of Energy,** New York: McGraw-Hill Book Company, Inc., 1959.

Boumphrey, Geoffrey, **Engines and How They Work,** 575 Lexington Avenue, New York: Franklin Watts, Inc., 1960.

Branley, Franklyn M., **Solar Energy,** New York: Thomas Y. Crowell Company, 1959.

Braymer, Daniel H. and Roe, A. C., **Rewinding Small Motors,** New York: McGraw-Hill Book Company, Inc., 1949.

Briggs and Stratton Four-Cycle Air Cooled Engine Repair Instructions, Milwaukee: Briggs and Stratton Corporation.

Briggs and Stratton Repair Instructions III and Supplement, Milwaukee: Briggs and Stratton Corporation.

Brockwell, P. T., Jr., **Major Appliance Servicing,** New York: McGraw-Hill Book Company, Inc., 1958.

Buehr, Walter, **The First Book of Machines,** New York: Franklin Watts, Inc., 1962.

Calder, Ritchie, **Evolution of the Machine,** Eau Claire, Wisc.: E. M. Hale & Company, 1968.

Campbell, Edward A., **How to Repair Home Appliances,** New York: Arco Publishing Company, Inc., 1957.

Carville, T. E. M., **Fractional Horsepower Motor Maintenance,** Scranton, Pennsylvania: The Haddon Craftsman, Inc., 1949.

Chandler, M. H., **Man: The Inventor,** Chicago: Rand McNally & Company, 1966.

Crouse, William H., **Electrical Appliance Servicing,** New York: McGraw-Hill Book Company, Inc., Trade Department, 1950.

Crow, Leonard R., **Learning Electricity Fundamentals,** Indianapolis: The Howard W. Sams Company, Inc., 1957.

Dalgliesh, Alice, **Ride on the Wind,** New York: Charles Scribner's Sons, 1956.

Darrow, Floyd L. and Hylander, Clarence J., **The Boy's Own Book of Great Inventions,** New York: The Macmillan Company Publishers, 1951.

Day, Richard, **Electrical Repairs,** 219 Park Avenue South, New York 10003: Arco Publishing Company, Inc., 1969.

De Camp, L. Sprague, **Engines: Man's Use of Power from the Water Wheel to the Atomic Pile,** New York: Golden Press, Publishers, 1959.

De Camp, L. Sprague, **Man and Power: The Story of Power from the Pyramids to the Atomic Age,** New York: Golden Press, Publishers, 1961.

Desoutter, D. M., **Your Book of Engines and Turbines,** New York: Transatlantic Arts, Inc.

Duffy, Joseph W., **Power: Prime Mover of Technology,** Bloomington, Ill.: McKnight & McKnight Publishing Company, 1965.

Dunsheath, Percy, **Electricity: How It Works,** New York: Thomas Y. Crowell Company, In USA by Vail-Ballow Press, Inc., Binghamton, New York, 1960.

Engines, New York: Golden Press, Inc., 1966.

Epstein, Samuel and Beryl, **All About Engines and Power,** New York: Random House, Inc., 1962

Floherty, John J. and McGrady, Mike, **Whirling Wings,** Philadelphia: J. B. Lippincott Company, E. Washington Square, 1960.

Glenn, Harold T., **Exploring Power Mechanics,** Peoria, Ill.: Charles A. Bennett Company, Inc., 1962.

Go-Power Ergine Analysis Systems, 155 Montgomery Street, San Francisco: Go-Power Corporation, 1966.

Graham, Kennard C., **Fundamentals of Electricity,** Chicago: American Technical Society, 1967.

Green, Philip T., **Electrical Testing and Troubleshooting,** New York: The Industrial Press, Inc., 1956.

Harris, Douglas J. and Robson, Peter N., **Vacuum and Solid State Electronics: An Introductory Course,** New York: Pergamon Press, Inc., 1963.

Harrison, George R., **The First Book of Energy,** New York: Franklin Watts, Inc., 1965.

Hertzberg, Robert, **Handyman's Electrical Repairs Handbook,** 219 Park Avenue South, New York: Arco Publishing Company, Inc., 1962.

Hertzberg Robert, **Repairing Small Electrical Appliances,** 219 Park Avenue South, New York: Arco Publishing Company, Inc., 1968.

Hibberd, R. G., **Solid-State Electronics,** New York: McGraw-Hill Book Company, Inc., 1968.

Hogben, Lancelot, **The Wonderful World of Energy,** New York: Doubleday & Company, Inc., 1959.

Hubert, Charles, **Preventative Maintenance of Electrical Equipment,** New York: McGraw-Hill Book Company, Inc., 1962.

Huey, Edward G., **What Makes the Wheels Go Round?,** New York: Harcourt, Brace & World, Inc., 1952.

Irving, Robert, **Energy and Power,** New York: Alfred A. Knopf, Inc., 1958.

Irwin, Keith G., **The Romance of Physics,** New York: Charles Scribner's Sons, 1966.

Judge, Arthur W., **Small Gas Turbines,** 105, 5th Avenue, New York 10003: Chapman & Hall, Barnes & Noble, Inc., 1960.

Keefe, John E., **Aim for a Job in Appliance Service,** 29 East 21st Street, New York 10010: Richards Rosen Press, Inc., 1967.

Kemp, Barron and McDonald, R. H., **Fundamentals of Modern Semi-Conductors,** New York: The Howard W. Sams Company, Inc., The Bobbs-Merrill Company, Inc., 1962.

Long, Kenneth, **Small Engines Service Manual,** Kansas City, Mo.: Technical Publications, Inc., 1966.

Magnetism and Electricity, P. O. Box 1919, Detroit: Educational Services, Department of Public Relations, Chrysler Corporation (Free).

Manly, H. P., **Electric Appliance Repair and Troubleshooting,** Chicago: Frederick J. Drake & Company, 1958.

Marcus, Abraham and Rebecca, B., **Power Unlimited,** Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1959.

McDonald, K. L., **Small Gasoline Engines Student Workbook,** Indianapolis: Bobbs-Merrill Company, Inc., pany, Inc., 4300 W. 62nd Street.

McPartland, Joseph F. and Novak, William J., Associate Editor, **Electrical Equipment Manual,** New York: McGraw-Hill Book Company, Inc., 1965.

McPartland, Joseph F. and Novak, William J., **Practical Electricity,** New York: McGraw-Hill Book Company, Inc., 1964.

Meyer, Jerome S., **Engines,** New York: The World Publishing Company, 1962.

Meyer, Jerome S., **Machines,** New York: The World Publishing Company, 1958.

Morgan, Alfred P., **Boys' Book of Engines, Motors and Turbines,** New York: Charles Scribner's Sons, 1956.

Morgan, Edward Dillman, **Maintenance of Inboard Engines,** 565, 5th Avenue, New York: Transatlantic Arts, Inc., 1967.

Newnham, Robert W., **Small Appliance Repairs,** New York: McGraw-Hill Book Company, Inc., 1967.

Notkin, Jerome J. and Gulkin, S., **How and Why Wonder Book of Machines,** Columbus, Ohio: Charles E. Merrill Books, Inc.

Pipe, Ted, **Small Gasoline Engines,** New York: The Howard W. Sams Company, Inc., 1967.

Pipe, Ted, **Small Gasoline Engines Training Manual,** New York: The Howard W. Sams Company, 1969.

Posin, Daniel Q., **What Is Energy?,** Chicago: Beckley-Cardy Company, 1968.

Power Mower Trouble Shooting, Jericho, New York: Automotive Mowers Associates Exposition, Exposition Press, Inc., 50 Jericho Turnpike.

Progress In Arresting, P. O. Box 662, Englewood, New Jersey: Lucas Electrical Services, Inc.

Purvis, Jud, **All About Small Gas Engines,** Chicago: The Goodheart-Willcox Company, Inc., 1960.

Rider, John F. and Prensky, Sol D., **How to Use Meters,** New York: John F. Rider Publisher, Inc., 1960.

Robbin, Irving, **How and Why Wonder Book of Basic Inventions,** Columbus, Ohio: Charles E. Merrill Books, Inc., 1965.

Roberson, Paul, **Engines,** New York: The John Day Company, 1965.

Rosenberg, Robert, **Electric Motor Repair,** Brooklyn, New York: Holt, Rinehart & Winston, Inc., Technical Division, 1960.

Rosenblatt, Jack and Friedman, M. Harold, **Direct and Alternating Current Machinery,** New York: McGraw-Hill Book Company, Inc., 1963.

Ruchlis, Hyman, **The Wonder of Heat Energy,** Evanston, Ill.: Harper and Row Publishers, El-Hi Division, 1961.

Sams, Howard W., **Basic Electricity and An Introduction to Electronics,** Indianapolis: The Howard W. Sams Company, Inc., 1967.

Schneider, Herman and Nina, **More Power to You,** New York: William R. Scott, Inc., 1958.

Schweitzer, Gerald, **Basics of Fractional Horsepower Motors and Repair,** New York: John F. Rider Publisher, Inc., 1960.

Sharp, Elizabeth N., **Simple Machines and How They Work,** New York: Random House, Inc., 1959.

Siskind, Charles S., **Alternating Current Armature Windings,** New York: McGraw-Hill Book Company, Inc., 1951.

Stephenson, George, **Power Mechanics,** Albany, New York: Delmar Publishers, Inc., 1963.

Stephenson, George, **Small Gasoline Engines,** Albany, New York: Delmar Publishers, Inc., 1964.

Stoddard, Edward, **The Story of Power,** New York: Garden City Books, 1956.

Technical Data, Louisville, Ky.: General Electric Major Appliance Division, Appliance Park.

Tricomi, Ernest, **How to Repair Major Appliances,** Indianapolis: The Howard W. Sams Company, Inc., 1968.

Turner, Rufus P., **Basic Electricity,** New York: Holt, Rinehart & Winston, Inc., 1967.

Turner, Rufus P., **Semi-Conductor Devices,** New York: Holt, Rinehart & Winston, Inc., 1961.

Wright, Forrest B., **Electricity in the Home and on the Farm,** New York: John Wiley & Sons, Inc., 1950.

Wyler, Rose and Ames, Gerald, **What Makes It Go?,** New York: McGraw-Hill Book Company, Inc., 1959.

Zim, Herbert S., **What's Inside of Engines?,** New York: William Morrow and Company, Inc., Publishers, 1953.